Energy Conservation Standards for Residential Furnaces and Boilers

Webcast Presentation

Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

August 17, 2004

Purpose: Prepare Stakeholders for the Public Meeting

- The Department wants to assist stakeholders in understanding and interpreting the material developed for the Advance Notice of Proposed Rulemaking (ANOPR)
- ANOPR Federal Register notice published July 29, 2004
- Focus on the spreadsheet tools developed for the ANOPR
- Explain how to use and apply the spreadsheet tools before the meeting

Webcast Protocol: Education & Familiarization Only

- Familiarize stakeholders with ANOPR spreadsheet tools
- Opportunity to ask clarification questions at the end of each section discussed today relating to the material presented
- The webcast is not part of the formal process and has no provision for capturing comments for the record
- This is not a forum to critique the ANOPR analysis
- The Department requests comments at the public meeting or in writing

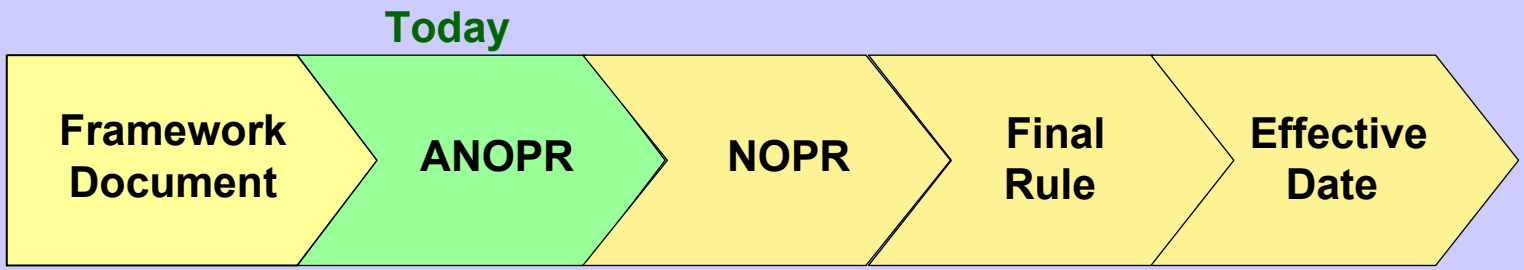
1 Rulemaking Overview

2 Engineering Analysis

3 Life-Cycle Cost Analysis

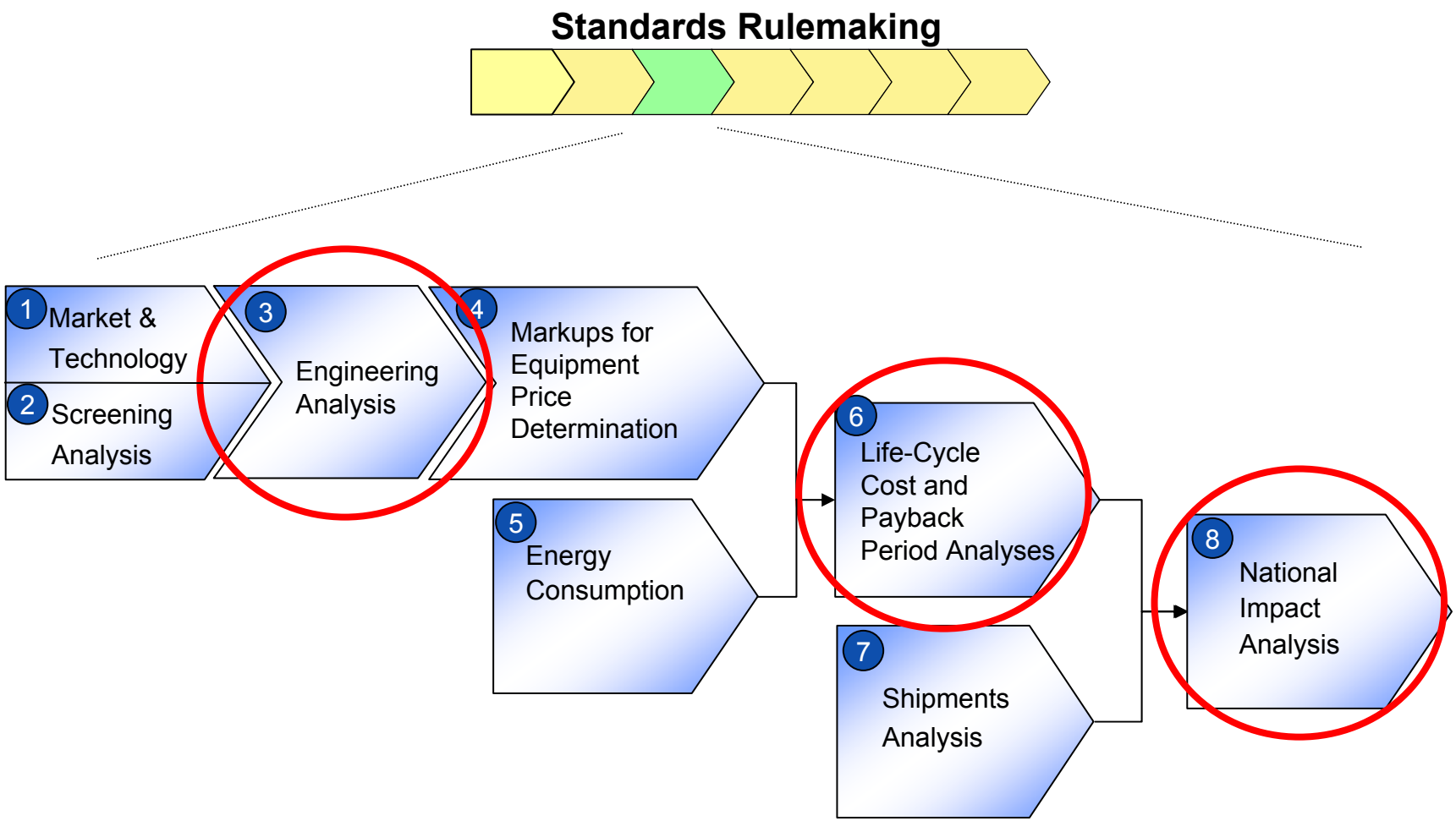
4 National Impact Analysis

Stages of the Rulemaking Process



- ✓ Federal Register Notices
- ✓ Written Comments
- ✓ Meetings and Oral Comments
- ✓ Web-posting Draft Analysis
- ✓ Consultative Meetings
- ✓ Webcasts

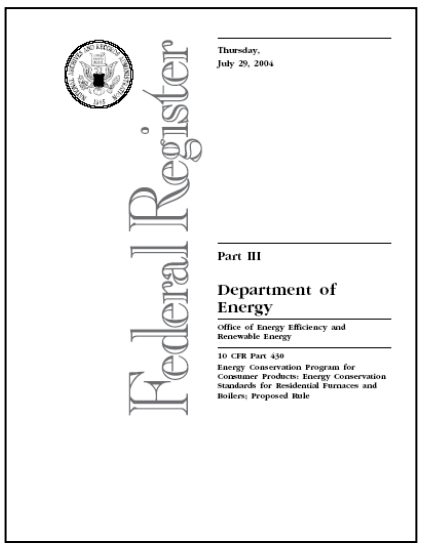
ANOPR Analyses Flow Diagram



ANOPR Documents and Material Published

www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html

- Federal Register Notice
- Technical Support Document (ANOPR version)
- Engineering Analysis (1 spreadsheet)
- Installation Model (2 spreadsheets)
- Life-Cycle Cost and Payback Period (6 spreadsheets)
- National Impact Analysis (2 spreadsheets)
- RECS Database & Reduced Furnace Model Database


Federal Register

Thursday,
July 29, 2004

Part III

Department of Energy

Office of Energy Efficiency and Renewable Energy

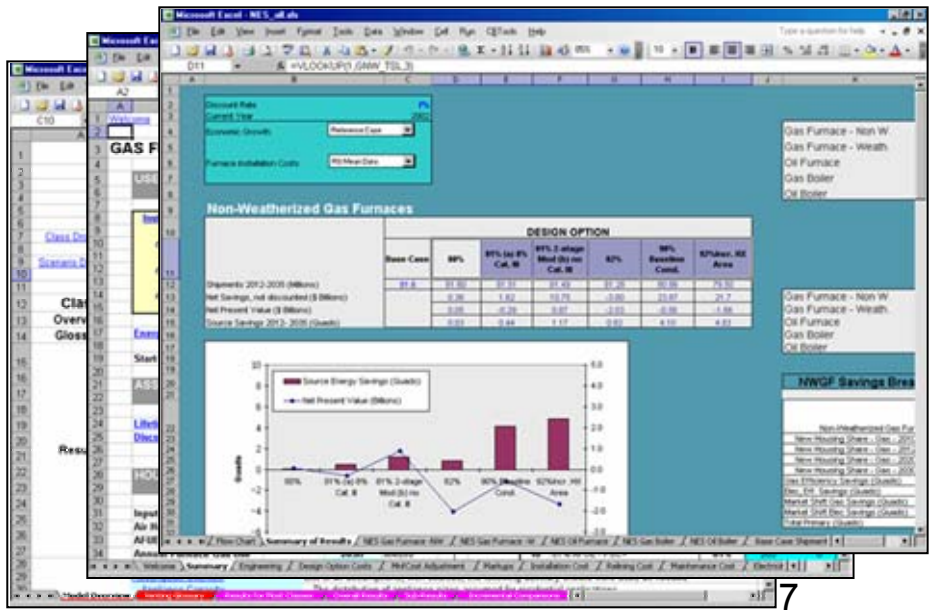
10 CFR Part 430
Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnaces and Boilers; Proposed Rule


TECHNICAL SUPPORT DOCUMENT:
ENERGY EFFICIENCY PROGRAM
FOR CONSUMER PRODUCTS:

ENERGY CONSERVATION STANDARDS FOR RESIDENTIAL FURNACES AND BOILERS

September, 2004

U.S. Department of Energy
Assistant Secretary
Office of Energy Efficiency and Renewable Energy
Building Technologies Program
Appliances and Commercial Equipment Standards
Washington, DC 20585



How to Submit Comments…

- Public Meeting on September 29, 2004 – oral comments will be captured in the transcript and become part of the public record.

- Written comments – comment period open until November 10, 2004. Reference docket #: EE–RM/STD–01–350 and/or RIN #: 1904–AA78.

Email: ResidentialFBANOPRComments@ee.doe.gov

Mail: Ms. Brenda Edwards-Jones
U.S. Department of Energy
BuildingTechnologies Program, Mailstop EE–2J
ANOPR for Residential Furnaces and Boilers
Docket number EE–RM/STD–01–350 and/or RIN number 1904–AA78
1000 Independence Avenue, SW.
Washington, DC 20585–0121

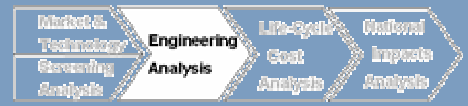
Courier: Ms. Brenda Edwards-Jones
U.S. Department of Energy
Building Technologies Program, Room 1J–018
1000 Independence Avenue, SW
Washington, DC 20585

1 Rulemaking Overview

2 Engineering Analysis

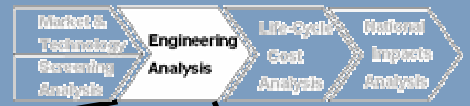
3 Life-Cycle Cost Analysis

4 National Impact Analysis

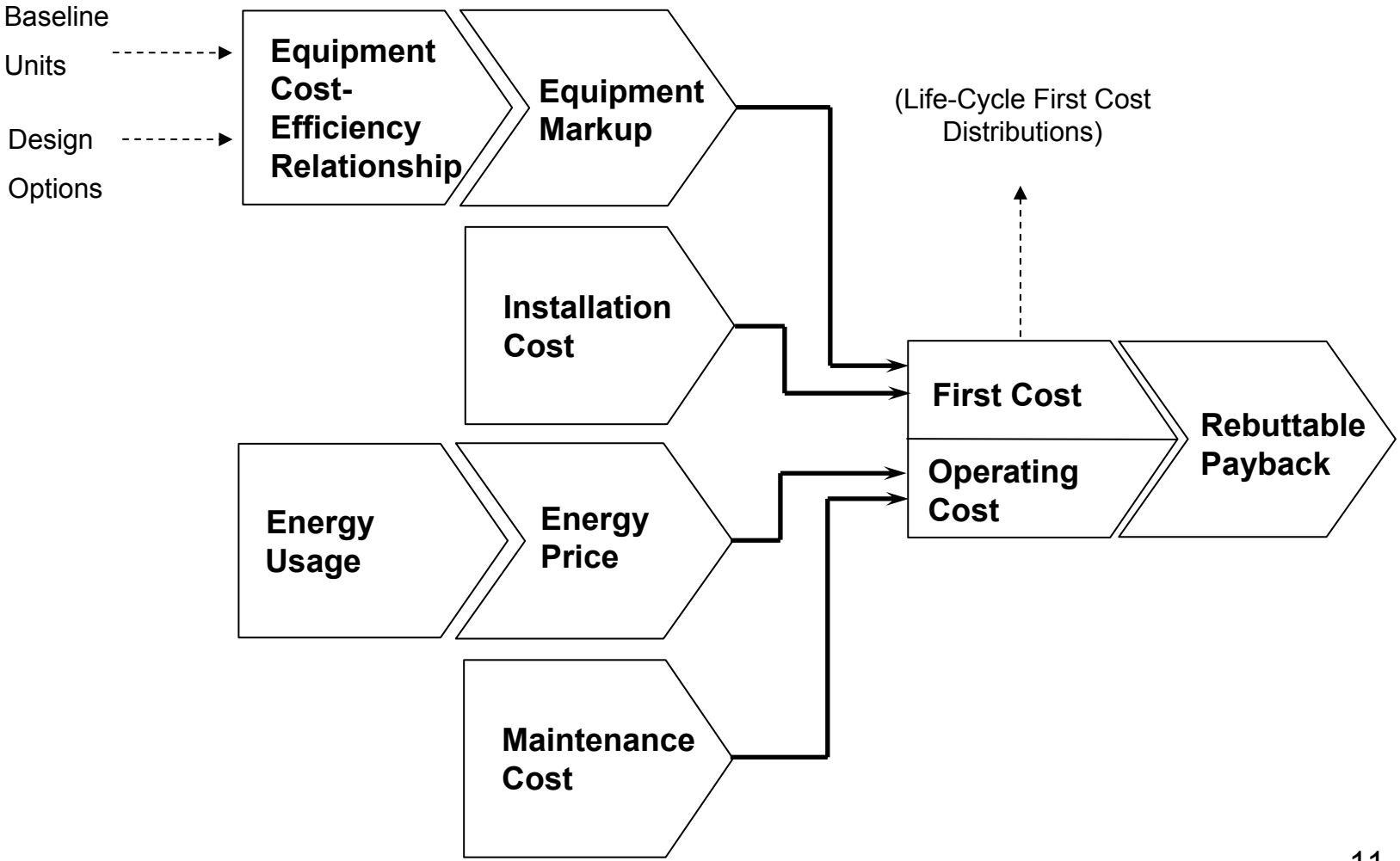


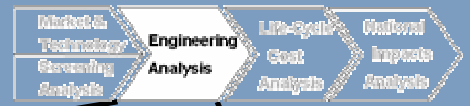
The purpose of the Engineering Analysis is to estimate the incremental energy savings potential and costs from increased equipment efficiency levels.

- Select efficiency increases (design options) relative to the baseline units
- Develop cost-efficiency relationships to show the equipment and installation costs of achieving increased efficiency
- Account for ranges and uncertainties in data and generate LCC input distributions
- Determine the simple payback for each efficiency level (design option) by calculating energy consumption based on the DOE test procedure (to satisfy NAECA rebuttable payback requirements)



Engineering Analysis Overview





Engineering Analysis Overview

Baseline Units

Design Options

Equipment Cost-Efficiency Relationship

Equipment Markup

(Life-Cycle First Cost Distributions)

Installation Cost

Energy Usage

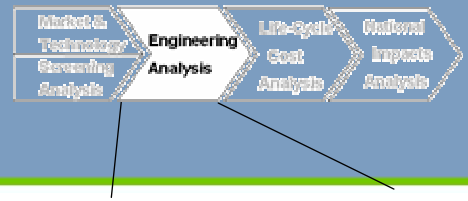
Energy Price

Maintenance Cost

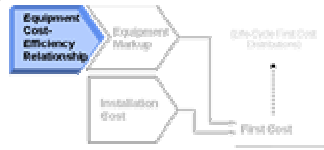
First Cost

Operating Cost

Rebuttable Payback

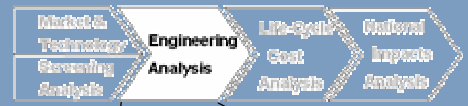


Baseline units are the lowest efficiency products available that meet current NAECA standards.

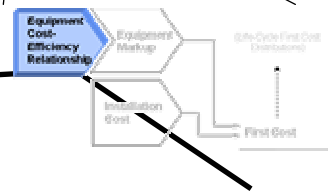


Equipment Type			Input Capacity[1] (Btu/hr)	Efficiency[2] (AFUE)	Conf. [3]	Heat Exchanger[3]	Ignition[3]	Draft[3]
Furnaces		Non-Weatherized Gas-Fired Furnaces	75,000	78	Upflow	Clam Shell or Tubular	Hot Surface	Induced
		Weatherized Gas-Fired Furnaces	75,000	75	Horizontal	Clam Shell or Tubular	Hot Surface	Natural
		Mobile Homes Gas-Fired Furnaces	70,000	75	Downflow	Drum	Standing Pilot	Natural
		Oil-Fired Furnaces	105,000	78	Upflow	Drum	Intermittent Ignition	Induced
Boilers		Gas-Fired Hot Water Boilers	140,000	80	N/A	Sectional, Dry-base, Cast Iron	Standing Pilot	Natural
		Oil-Fired Hot Water Boilers	105,000	80	N/A	Sectional, Wet-base, Cast Iron	Intermittent Ignition	Induced

Sources:
[1] Stakeholders' Input
[2] NAECA Minimum Standards
[3] Manufacturer Interviews, Market Assessment



Equipment Cost-Efficiency Process

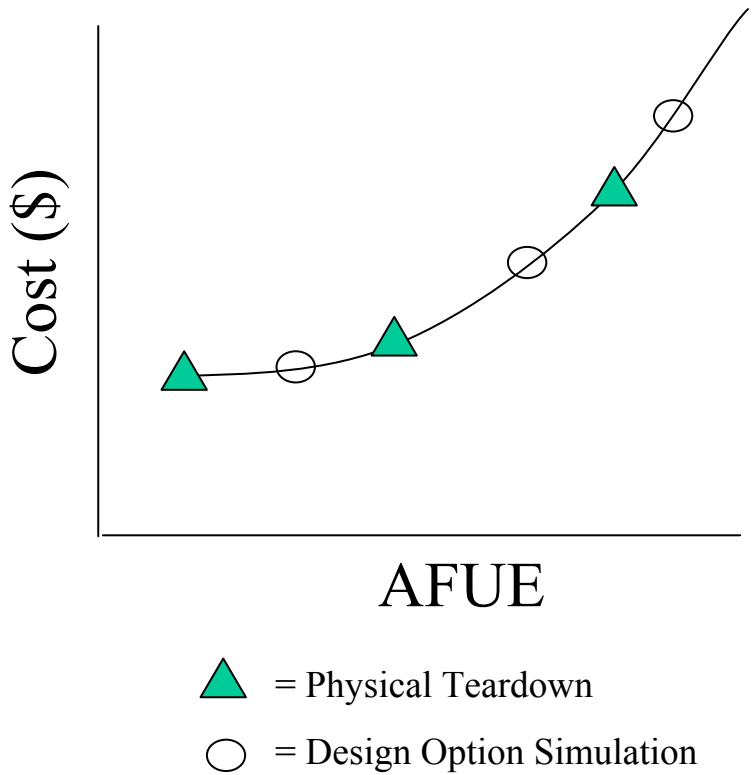


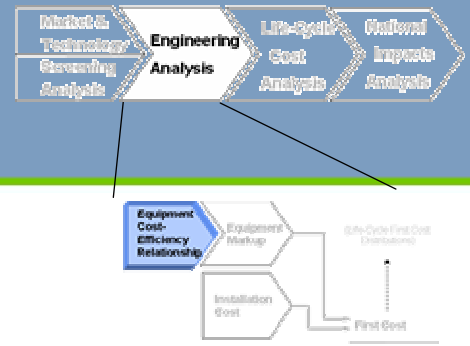
1) **Define Baseline Units**

2) **Perform Physical Teardowns**
   - Select Teardown Units
   - Develop Bill of Materials
   - Cost Model Assumptions

3) **Design Option Simulations**
   - Identify Design Options
   - Performance Model AFUE
   - Cost Design Options

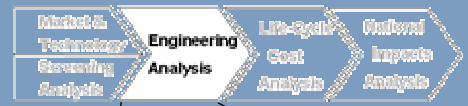
4) **Stakeholder Review, Finalize**

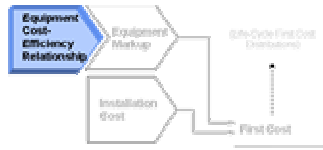




Engineering Spreadsheet File Structure

Sheet	Type	Contents
Introduction	Overview	Worksheet instructions
Data	Inputs	All inputs
NonWeath Gas Furnace	Class Calculations	Contains first costs (equipment + installation), and operating costs (repair/maintenance + energy), and simple first year paybacks in 2012 for each product class at each efficiency level.
Weath Gas Furnace		
MH Gas Furnace		
Oil Furnace		
Gas Boiler		
Oil Boiler		
InstallationCostScenarios	Scenario Selector	Installation data switches
TP-SingleStageCtrl	Energy Calculations	Burner operating hours (BOH) and furnace/boiler average annual electrical energy consumption (Eae) for each product class at each efficiency level.
TP-TwoStageCtrl		
TP-StepModCtrl		
Table-Lookup	Lookup Tables	For energy calculations



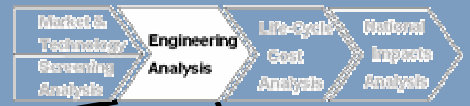


The incremental manufacturing cost results are on the class calculation sheets.

	A	B	C	D	E	F	G	H	I
1	NON-WEATHERIZED GAS FURNACE								Installation Mod
2			Cost Data						
3			Mfr Costs (per unit)						Consumer Co
4			Material	Labor	Transportation	Overhead	Total	Incremental	Retail
5	ID	Efficiency Levels & Design Options	$	$	$	$	$	$	$
6	0	78%AFUE - Baseline Non-Weatherized	$232.79	$57.76	$19.62	$31.16	$341.33		$1,086.42
7	1.1	80%AFUE (A) - Increased HXArea	$234.69	$58.55	$19.62	$31.62	$344.48	$3.14	$1,093.03
8	1.1.1	80%AFUE (A1) - ImprovedCircBlowerMotor (PSC)	$237.69	$58.55	$19.62	$31.62	$347.48	$6.14	$1,099.33
9	1.1.2	80%AFUE (A2) - ImprovedCircBlowerMotor(ECM)	$337.69	$58.55	$19.62	$31.62	$447.48	$106.14	$1,309.50
10	1.1.3	80%AFUE (A3) - ImprovedCircBlowerMotor(SR)	$337.69	$58.55	$19.62	$31.62	$447.48	$106.14	$1,309.50
11	1.1.4	80%AFUE (A4) - ImprovedCircBlowerImpeller w/ PSC	$293.25	$58.55	$39.54	$31.62	$422.95	$81.62	$1,257.96
12	1.1.5	80%AFUE (A5) - ImprovedCompactCircBlowerImpeller + ECM	$359.20	$58.55	$19.62	$31.62	$468.99	$127.65	$1,354.71
13	1.2	80%AFUE (B) - Improved Heat Transfer Coef	$235.22	$61.82	$19.62	$32.50	$349.16	$7.82	$1,102.87
14	1.2.1	80%AFUE (B1) - ImprovedCircBlowerMotor(PSC)	$238.22	$61.82	$19.62	$32.50	$352.16	$10.82	$1,109.17
15	1.2.2	80%AFUE (B2) - ImprovedCircBlowerMotor(ECM)	$338.22	$61.82	$19.62	$32.50	$452.16	$110.82	$1,319.34
16	1.2.3	80%AFUE (B3) - ImprovedCircBlowerMotor(SR)	$338.22	$61.82	$19.62	$32.50	$452.16	$110.82	$1,319.34
17	1.2.4	80%AFUE (B4) - ImprovedCircBlowerImpeller w/ PSC	$293.78	$61.82	$39.54	$32.50	$427.63	$86.30	$1,267.80
18	1.2.5	80%AFUE (B5) - ImprovedCompactCircBlowerImpeller + ECM	$359.73	$61.82	$19.62	$32.50	$473.67	$132.34	$1,364.55
							62	$31.62	$366.38	$25.19	$1,139.37
							62	$31.62	$369.53	$28.19	$1,145.68
							62	$31.62	$469.53	$128.19	$1,355.85
							54	$31.62	$464.92	$123.59	$1,346.17
							62	$31.62	$528.08	$186.75	$1,478.91
							62	$31.89	$347.56	$6.22	$1,099.50
							62	$31.89	$350.56	$9.22	$1,105.81
							62	$31.89	$450.56	$109.22	$1,315.98
							62	$31.89	$450.56	$109.22	$1,315.98
							54	$31.89	$426.03	$84.70	$1,264.43
							62	$31.89	$472.07	$130.73	$1,361.18
							62	$32.61	$350.43	$9.10	$1,105.54
							62	$32.61	$353.43	$12.10	$1,111.85
							62	$32.61	$453.43	$112.10	$1,322.02
							62	$32.61	$453.43	$112.10	$1,322.02

Gas Boiler | Oil Boiler | TP-SingleStageCtrl | TP-Two

	C	D	E	F	G	H
						Installa
	Cost Data					
Mfr Costs (per unit)						Co
	Material	Labor	Transportation	Overhead	Total	Incremental
	$	$	$	$	$	$
	$232.79	$57.76	$19.62	$31.16	$341.33	
	$234.69	$58.55	$19.62	$31.62	$344.48	$3.14



Engineering Analysis Overview

Baseline Units

Design Options

Equipment Cost-Efficiency Relationship

Equipment Markup

(Life-Cycle First Cost Distributions)

Installation Cost

First Cost

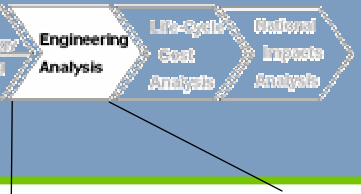
Operating Cost

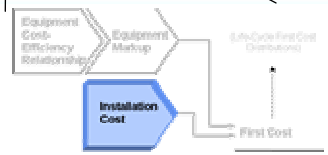
Rebuttable Payback

Energy Usage

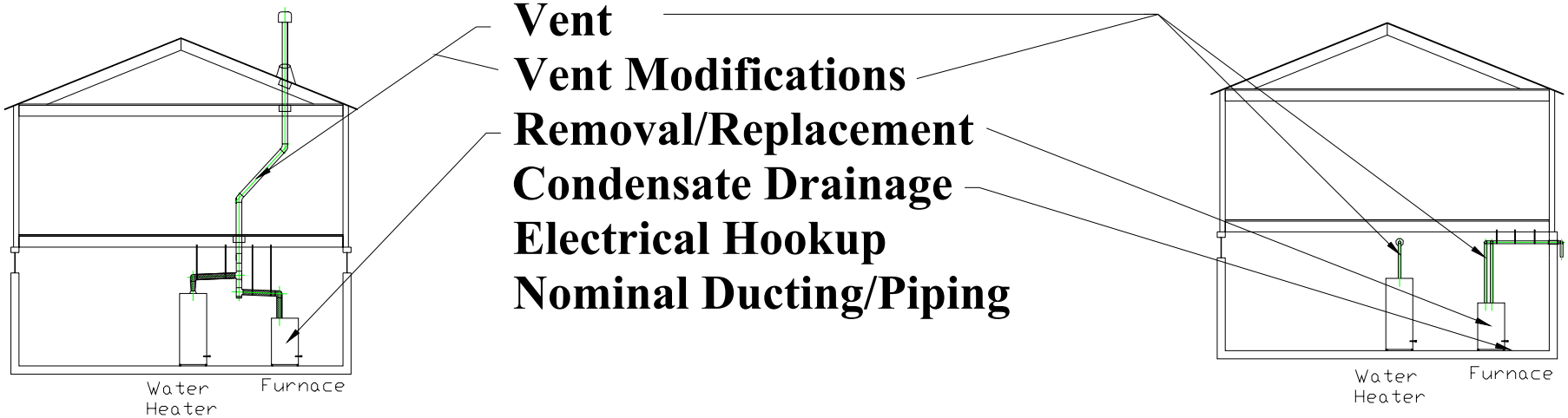
Energy Price

Maintenance Cost

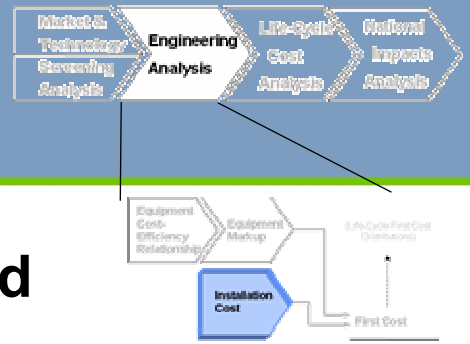




Installation Cost Components



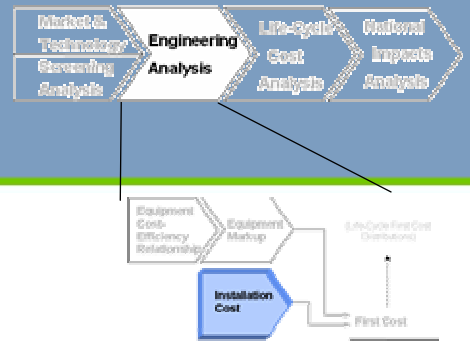
Installation costs are usually higher than the equipment cost, and vary with efficiency, installation configuration, and installation size.



Installation Cost Sources Initially Considered

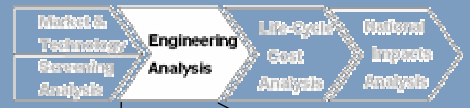
Data Source	Sample Size	Geographic Spread	Source Breadth	Comment
1994 GRI Report Inflation index updated in 2002	34	USA	Wide	New = replacement markets; no detailed data
1999 NR Canada study	>16	4 Canadian cities	Narrow	Applicable to new construction condensing furnaces
1996 Wisconsin Energy Center	12	Wisconsin	Narrow	
Bill of Material Cost Model	>1500	USA	Wide	Widely used by contractors for bidding

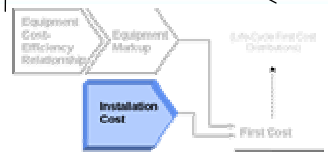
The Department created its own installation cost model, based on the widely used RS Means construction-cost estimation method, and this model agrees with the above sources when equivalent assumptions are used.



Installation Model File Structure

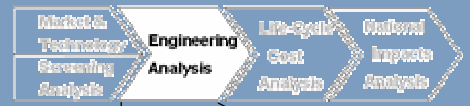
Installation Model, Selected Sheets	Type	Contents
Model Overview	Overview	Sheet Description and Contents, with hyperlinks
Glossary	Venting Terms	List of Venting Terms and Definitions
Results for Most Classes	Results	Installation Cost Efficiency Tables
Overall Results		Top-level results for each Candidate Standard Level
Sub-Results		Absolute cost breakdowns for each candidate standard level; weighting applied here.
Master BOM		BOM w/ activated lines
Assumption Overview	Assumptions	List of all assumptions and sources
Controls	Model Calculations	Model input and output sheet
SSE-AFUE Summary	SSE-AFUE Calculations	Summary for all classes; data and assumptions in "SSE-AFUE Analysis.xls"

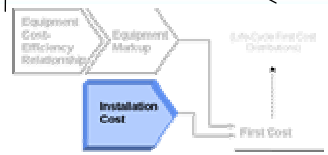




Installation Model Cost Calculation Steps

1	Config-uration	**Vent Configuration** –	Nationally weight averaged according to prevalence in the field.
2	Bill of Material	**Bill of Material (BOM)** –	Single venting configuration BOMs are determined from installation manuals.
3	Quantity	**Line Item Quantity** –	"Installation size"-related parameters (vent length & diameter, etc.) are calculated using a Monte Carlo simulation.
4	Material + Labor	**Material & Labor** –	Material quotations and RS Means labor cost estimates.





Step 1: Vent Configuration - Common Configurations

Config-uration

Bill of Material

Quantity

Material + Labor

Market

Furnace Category

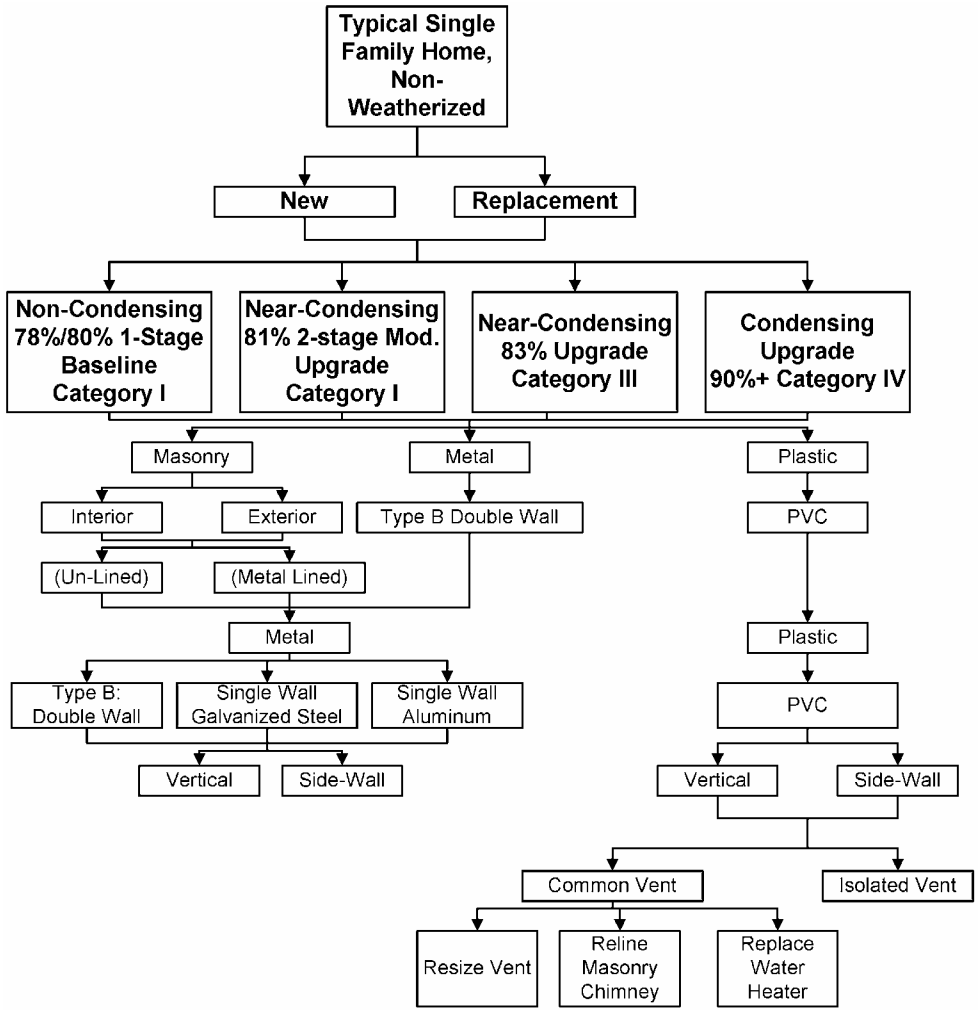
Existing Vent Type

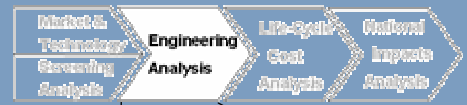
Chimney Liner

Existing Vent Connector

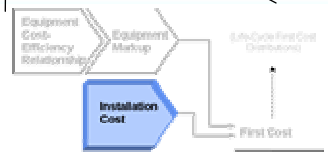
Vent Orientation

Water Heater Venting





Step 1: Vent Configuration - Weighting



Config-uration

Bill of Material

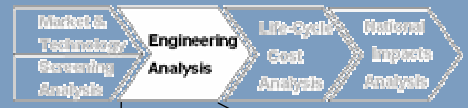
Quantity

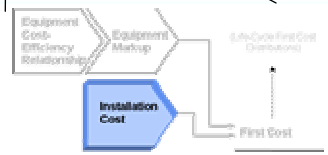
Material + Labor

Total Cost — **NW Gas Furnace** — Model Overview

Baseline: Non-Condensing 80% AFUE Vertical Vent

Market	WH Options \ Vent / Vent Conn	Masonry (23%) Unlined		Masonry (27%) Lined		Type B Double Wall(32%)		Plastic (6%)	Other (11%)	Weighted Average	Weighted Market Average	Candidate Standard Level Weighted Average
		Single Wall (53%)	Double Wall (36%)	Single Wall (53%)	Double Wall (36%)	Single Wall (53%)	Double Wall (36%)	Plastic (6%)	Other (5%)			
Replacements (75%)	Water Heater Isolated (50%)	$824	$841	$525	$529	$525	$529			$612	$625	$738
	Water Heater Common (50%)	$909	$945	$525	$529	$525	$529			$638		
New (25%)	Water Heater Isolated (50%)	$980	$1,000	$980	$1,000	$1,150	$1,170			$1,054	$1,076	
	Water Heater Common (50%)	$980	$1,000	$1,051	$1,071	$1,204	$1,223			$1,098		
Weighting		17%	11%	20%	13%	23%	16%					





Step 1: Vent Configuration - Vent Category (Non-weatherized Gas Furnaces)

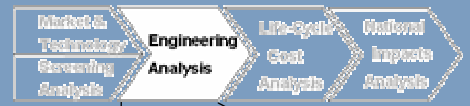
Config-uration

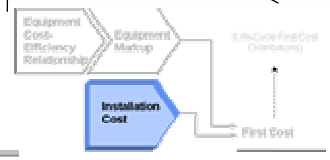
Bill of Material

Quantity

Material + Labor

Efficiency Level	Vent Assumption
78% AFUE	Category I (steel)
80% AFUE	Category I (steel)
81% 2-stage Modulating	Category I (steel), Type B vent connector required
81% 1-stage	92% Category I (steel) 8% Category III (stainless steel)
82%	65% Category I (steel) 35% Category III (stainless steel)
83%	Category III (stainless steel)
90% Condensing	Category IV (plastic)





Step 2: Bill of Material (BOM)

- Config-uration
- Bill of Material
- Quantity
- Material + Labor

Bill of Materials — Baseline 80% Replacement Unlined Masonry SWVC IsolatedWH

Baseline 80% Replacement Unlined Masonry SWVC IsolatedWH
Baseline 80% Replacement Unlined Masonry DWVC IsolatedWH
Baseline 80% Replacement Lined Masonry SWVC IsolatedWH
Baseline 80% Replacement Lined Masonry DWVC IsolatedWH
Baseline 80% Replacement Type B SWVC IsolatedWH
Baseline 80% Replacement Type B DWVC IsolatedWH
Baseline 80% Replacement Unlined Masonry SWVC CommonWH
Baseline 80% Replacement Unlined Masonry DWVC CommonWH

Category	Item #						
Gas Piping	1						
	2						
Ductwork	3						
Vent Installation	4		0	feet	$0.00	0.0	$0
	5		0	ea	$0.00		
	6		0	ea	$0.00		
	7		0	ea	$0.00		
	8		0	ea	$0.00		
	9		0	ea	$0.00		
	10		0	ea	$0.00		
	11		0	ea	$0.00		
	12		0	ea	$0.00		
Vent Connector @91%	13	Chimney vent, type SW, 3 inch Diameter	5	feet	$6.01	1.7	$86
	14	Type SW,Elbows, 3 inch Diameter	1	ea	$2.57		
	15	1/2 in wide galv steel strapping	2	ea	$0.18		
Relining @91%	16	Flexible 2 ply Al Liner w/flash, cap, mortar collar 4 in Dia"	24	feet	$93.24	2.8	$236
	17	Connector	1	ea	$22.84		
Furnace	18	100 MBH Furnace-- site & connect	1	ea	$0.00	7.5	$350
Electrical Hookup	19	Thermostat hookup, low voltage wire, heat + cool	1	ea	$24.26	0.4	$45
Water Heater	20		0	ea	$0.00	0.0	$0
	21		0	feet	$0.00		
	22		0	ea	$0.00		
	23		0	ea	$0.00		
Drainage	24		0	feet	$0.00	0.0	$0
	25		0	ea	$0.00		
		Totals			$163	14.8	$824

Weighting Basis: 2012 National Average **Class:** NW Gas Furnace

Orphaned WH Consumer Options | Master BOM | Sensitivity Results | Regional Incrementals | Venting Options | Assump

Step 3: Line Item Quantity - Installation Size-related Parameters

Config-uration

Bill of Material

Quantity

Material + Labor

Size-Related Parameters:

Vent Connector Diameter: 3" Non-condensing, 2" Condensing. Product Literature research (+1" added for larger d

Vent Diameter: 3-5", nominal 4" for non-condensing; 2" for condensing. NFGC Calculations. (+1" added for larger d

Type B Vent Diameter			No Water Heater	Water Heater Size (kBTU)	
			0	30	50
Furnace Size (kBTU)	40	10' H	3"	4"	4"
		50' H	3"/NA	4"	4"
	75	10' H	4"	5"	5"
		50' H	3"/4"	4"	4"
	150	10' H	4"/5"	6"	7"
		50' H	4"/5"	5"	5"

For each element in the above matrix, tables 13.1 (Type B no Water Heater) and 13.6 (Type B w/water heater) of the NFGC were used to look up applicable vent diameters. 2' connector rise was assumed.

Number of Elbows: 1-3 Non-condensing, 6-8 Condensing depending on configuration:

Nominal Number of Tees/Elbows	Masonry	Masonry Lined	Type B	Plastic
Electric Water Heater (Isolated)	0/1	0/1	1/1	0/6
Gas Water Heater (Common)	0/2	1/3	2/3	0/8

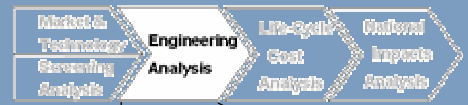
Appliance Capacity:

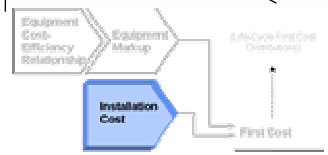
Non-weatherized Gas Furnaces: 40-150 kBTU input, 80 kBTU nominal.

Derived from LCC runs, which correlated RECS data with the age and size of the house, and historical GAMA shipment dat

Gas Boilers: Same as non-weatherized gas furnaces, except 140 kBTU nominal

Venting Options | Assumptions Overview | Appliance Capacity | RECS Data | Regional Weighting | Crew Labor Rates | M





Step 4: Material & Labor - Line Item Costs

Config-uration

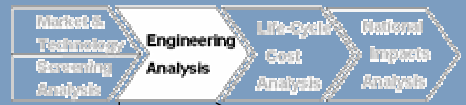
Bill of Material

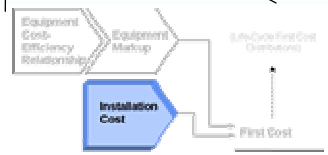
Quantity

Material + Labor

	A	B	C	D	E	F	G	H	I	J	K
1		Model Overview				2003 List Prices					
2	Item No.	Item Description	Dia-meter	Unit	Avg List Price per Unit	McMaster	Grainger	Little Giant Pumps	B-Vent	Lowes	Zflex
3	1	1/2" x X" Pipe Nipple, Sch. 40, Black Iron NPT		ea.	$0.53	$0.53					
4	2	1/2" Union, NPT		ea.	$3.49	$3.49					
5	3	Flexible Perforated Steel Hanger Straps		ft.	$0.10	$0.10					
6	4	Type B double wall vent, Random length	3"	ea.	$3.95						
7	5		4"	ea.	$5.98						
8	6		5"	ea.	$6.21						
9	7		6"	ea.	$7.23						
10	8	Type B 90 elbows	3"	ea.	$15.21		$15.21				
11	9	(Some adjustable)	4"	ea.	$19.26		$17.94		$25.00	$14.84	
12	10		5"	ea.	$20.97		$20.97				
13	11		6"	ea.	$24.91		$24.91				
14	12	Type B Adjustable Length	3"	ea.	$7.51		$8.04			$6.98	
15	13		4"	ea.	$12.21		$9.42		$15.00		
16	14		5"	ea.	$11.17		$11.17				
17	15		6"	ea.	$12.03		$12.03				
18	16	Type B wall thimble	3"	ea.	$6.59		$4.33			$8.84	
19	17	(Bucket)	4"	ea.	$4.33		$4.33				
20	18		5"	ea.	$6.86		$6.86				
21	19		6"	ea.	$8.86		$8.86				
22	20	Roof flashing, storm collar	3"	ea.	$8.44		36.35			$8.44	
23	21	(Grainger Kits incl. Draft hood connector	4"	ea.	$16.36	$9.71	38.75		$23.00		

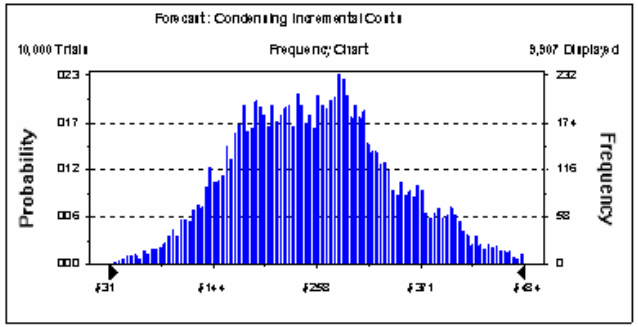
RECS Data | Regional Weighting | Crew Labor Rates | Material Database | Water Heater Equipment Estimate | 2012





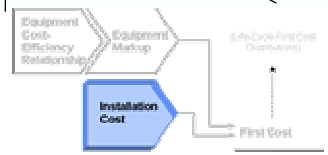
Sensitivity Analysis

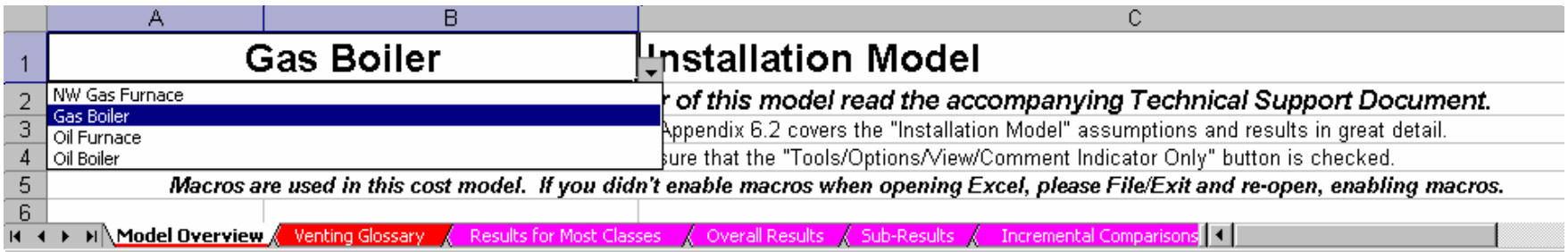
	A	B	C	D	E	F	G	H	I	J
581	**Forecast: Condensing Incremental Costs**								**Overall Results - Cell: C8**	
582										
583	Summary:									
584	Display Range is from $31 to $484									
585	Entire Range is from ($5) to $605									
586	After 10,000 Trials, the Std. Error of the Mean is $1									
587										
602										
603										
604										
605										
606										
607										
608										
609										
610										
611										
612										
613										
614										
615										
616										
617										
618										
619										
620										
621										
622	**Forecast: NWGF 80% AFUE Total Average**								**Overall Results - Cell: B2**	
623										
624	Summary:									
625	Display Range is from $566 to $868 $									
626	Entire Range is from $544 to $996 $									
627	After 10,000 Trials, the Std. Error of the Mean is $1									
628										



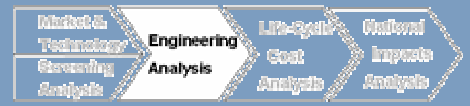
Master BOM | Sensitivity Results | Regional Incrementals | Venting Options | Assumptions Overv

Class Dropdown Switch





1	Rulemaking Overview
2	**Engineering Analysis (Rebuttable Payback)**
3	Life-Cycle Cost Analysis
4	National Impact Analysis



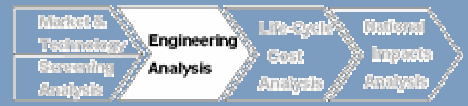
Rebuttable Payback

- EPCA requires DOE to recalculate a "rebuttable payback."

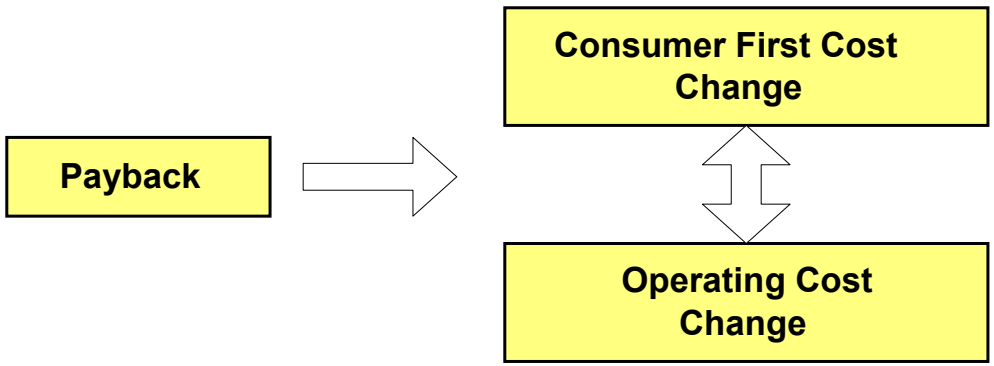
  * "(iii) If the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure, there shall be a rebuttable presumption that standard is economically justified;"

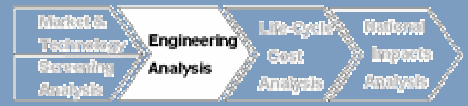
- Calculations shall be performed using the DOE test procedure.
- Rebuttable payback differs from the LCC payback, which reflects field conditions.

*per (42 U.S.C. 6295 (l)(2)(B)(i)(V)(iii) Part B of Title III of the Energy Policy and Conservation Act (EPCA), Public Law 94–163—as amended by the National Appliance Energy Conservation Act (NAECA) of 1987

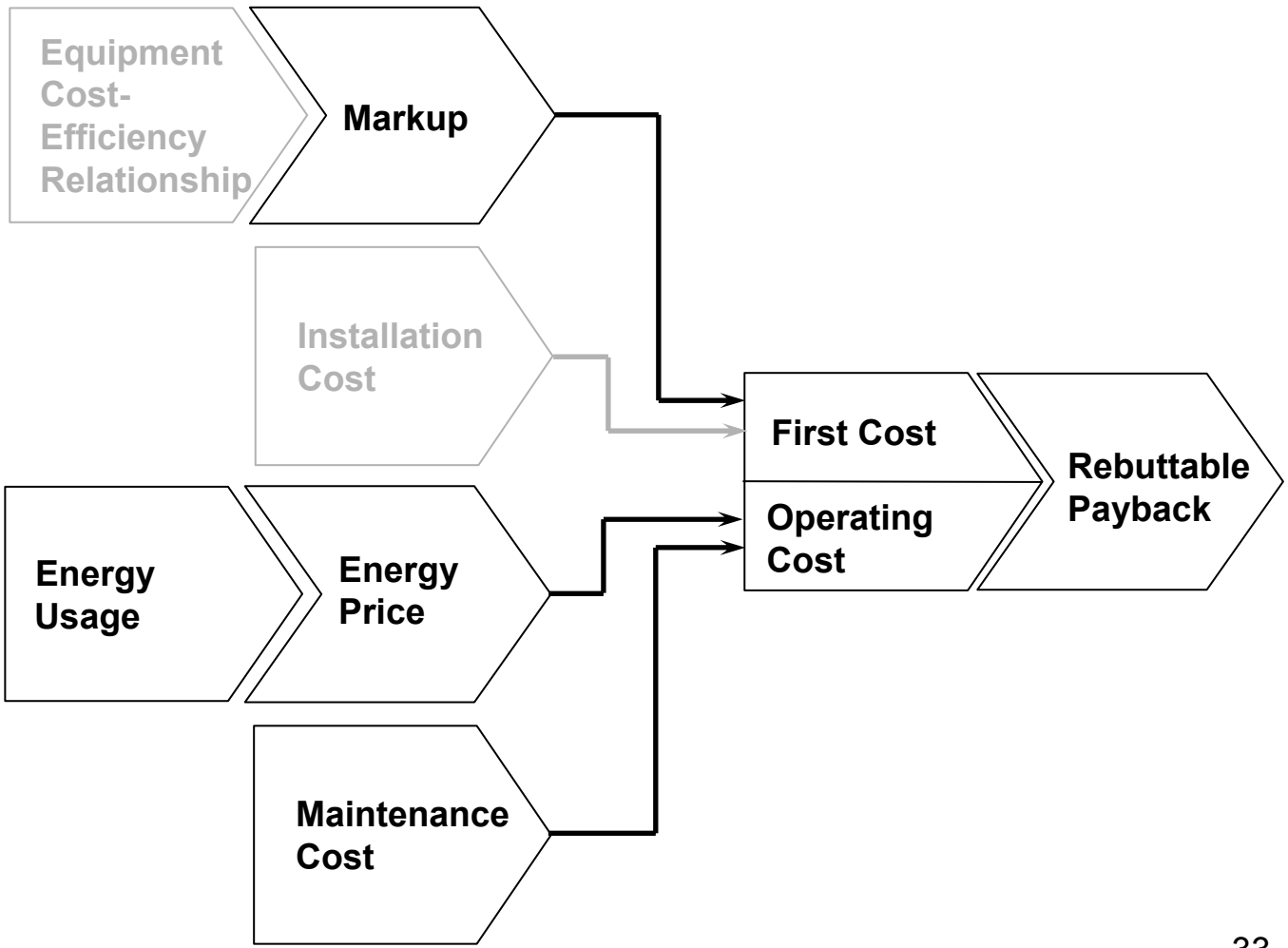


Rebuttable Payback





Rebuttable Payback Overview



The markup results are on the class calculation sheets.

B13 oilboiler_base_ignitor

	A	B	C	D	E
1	DATA WORKSHEET				
2	Definition	Variable Name	Value	Units	Comments
101	**Markups / Sales Tax**				
102	Mfr Markup	mfr_markup	1.26	-	Markup applied by the furnace manufacturer.
103	Wholesaler Markup	distr_markup			
104	Incremental Wholesaler Markup	incr_distr_markup			
105	Contractor Markup	contr_markup			
106	Incremental Contractor Markup	incr_contr_markup			
107	Manufactured Home Manufacturer and Distributor Markup	MH_mfr_distr_markup			
108	Builder Markup	bld_markup			
109	Incremental Builder Markup	incr_bld_markup			
110	Sales Tax	sales_tax			
111	Markup on the BASELINE cost (gas furnaces)	markup_base_cost			

NON-WEATHERIZED GAS FURNACE — Installation Mod

Cost Data

ID	Efficiency Levels & Design Options	Mfr Costs (per unit) Material $	Labor $	Transportation $	Overhead $	Total $	Consumer Costs Incremental $	Retail $
0	78%AFUE - Baseline Non-Weatherized	$232.79	$57.76	$19.62	$31.16	$341.33		$1,086.42
1.1	80%AFUE (A) - Increased HXArea	$234.69	$58.55	$19.62	$31.62	$344.48	$3.14	$1,093.03
1.1.1	80%AFUE (A1) - ImprovedCircBlowerMotor (PSC)	$237.69	$58.55	$19.62	$31.62	$347.48	$6.14	$1,099.33
1.1.2	80%AFUE (A2) - ImprovedCircBlowerMotor(ECM)	$337.69	$58.55	$19.62	$31.62	$447.48	$106.14	$1,309.50
1.1.3	80%AFUE (A3) - ImprovedCircBlowerMotor(SR)	$337.69	$58.55	$19.62	$31.62	$447.48	$106.14	$1,309.50
1.1.4	80%AFUE (A4) - ImprovedCircBlowerImpeller w/ PSC	$293.25	$58.55	$39.54	$31.62	$422.95	$81.62	$1,257.96
1.1.5	80%AFUE (A5) - ImprovedCompactCircBlowerImpeller + ECM	$359.20	$58.55	$19.62	$31.62	$468.99	$127.65	$1,354.71
1.2	80%AFUE (B) - Improved Heat Transfer Coef	$235.22	$61.82	$19.62	$32.50	$349.16	$7.82	$1,102.87

C D E F G H I

Installation Mod

Cost Data

Mfr Costs (per unit) Consumer Co

Material $ | Labor $ | Transportation $ | Overhead $ | Total $ | Incremental $ | Retail $

$232.79 | $57.76 | $19.62 | $31.16 | $341.33 | | $1,086.42

$234.69 | $58.55 | $19.62 | $31.62 | $344.48 | $3.14 | $1,093.03

Data | NonWeath Gas Furnace | Weath Gas Furnace | MH Gas Furnace | Oil Furnace | Gas Boiler | Oil Boiler | TP-SingleStageCtrl | TP-Two

Energy Usage Calculations

BOH & Eae Calculations (per CFR 10.2) for Equipment w/ Single Stage Controls

Model Number	Q_{IN} BTU/h	Q_{OUT} BTU/h	R	t_P sec	y	y_{IO}	y_P	RDHR kBTU/h	A hr/kBTU	B	BOH_{88} hr/yr	E_{AE} kWh
Non-Weatherized Gas Furnaces												
Gas Furnace, 7 8% w/time delays, w/o pilot	75,000	57,809	1.0	0	1.13	0.16	1.00	30	0.01649	0	792	558
Gas Furnace, 80%(A) w/time delays, w/o pilot	75,000	58,704	1.0	0	1.13	0.16	1.00	30	0.02	0	773	545
80%(A1) - ImprovedCircBlowerMotor (PSC)	75,000	59,742	1.0	0	1.13	0.16	1.00	30	0.02	0	774	532
80%(A2) - ImprovedCircBlowerMotor(ECM)	75,000	59,135	1.0	0	1.13	0.16	1.00	30	0.02	0	[illegible]	459
80%(A3) - ImprovedCircBlowerMotor(SR)	75,000	59,264	1.0	0	1.13	0.16	1.00	30	0.02	0	776	487
80%(A4) - ImprovedCircBlowerImpeller w/ PSC	75,000	59,482	1.0	0	1.13	0.16	1.00	30	0.02	0	777	480
80%(A5) - ImprovedCompactCircBlowerImpeller + ECM	75,000	58,725	1.0	0	1.13	0.16	1.00	30	0.02	0	781	[illegible]
Gas Furnace, 81% w/time delays, w/o pilot	75,000	59,475	1.0	0	1.13	0.16	1.00	30	0.02	0	764	538
81%(A1) - ImprovedCircBlowerMotor (PSC)	75,000	59,475	1.0	0	1.13	0.16	1.00	30	0.02	0	765	525
81%(A2) - ImprovedCircBlowerMotor(ECM)	75,000	59,475	1.0	0	1.13	0.16	1.00	30	0.02	0	769	453
81%(A3) - ImprovedCircBlowerMotor(SR)	75,000	59,475	1.0	0	1.13	0.16	1.00	30	0.02	0	767	481
81%(A4) - ImprovedCircBlowerImpeller w/ PSC	75,000	59,475	1.0	0	1.13	0.16	1.00	30	0.02	0	768	475
81%												
Gas Fu												
82%												
82%												
82%												
82%												
82%												
Gas Fu												
Gas Fu												
90%	75,000	57,809	1.0	0	1.13	0.16	1.00	30	0.0164	0	792	558
90%(A2) - ImprovedCircBlowerMotor(ECM)	75,000	66,225	1.0	0	1.13	0.16	1.00	40	0.01	0	925	545
90%(A3) - ImprovedCircBlowerMotor(SR)	75,000	66,225	1.0	0	1.13	0.16	1.00	40	0.01	0	923	579
90%(A4) - ImprovedCircBlowerImpeller w/ PSC	75,000	66,225	1.0	0	1.13	0.16	1.00	40	0.01	0	924	571
90%(A5) - ImprovedCompactCircBlowerImpeller + ECM	75,000											
Gas Furnace, 92% w/time delays, w/o pilot	75,000											
92%(A1) - ImprovedCircBlowerMotor (PSC)	75,000											
92%(A2) - ImprovedCircBlowerMotor(ECM)	75,000											
92%(A3) - ImprovedCircBlowerMotor(SR)	75,000											

MH Gas Furnace | Oil Furnace | Gas Boiler | Oil Boiler

NON-WEATHERIZED GAS FURNACE

ID	Efficiency Levels & Design Options	Energy Use Data: BOH hr	Fuel MBtu/yr	Electric kWh/year
0	78%AFUE - Baseline Non-Weatherized	792	59.42	558
2.3	81%AFUE (C) - Modulation (2-stage)	985	73.85	656
2.3.1	81%AFUE (C1) - ImprovedCircBlowerMotor(PSC)	987	73.99	640
2.3.2	81%AFUE (C2) - ImprovedCircBlowerMotor(ECM)	997	74.81	553
2.3.3	81%AFUE (C3) - ImprovedCircBlowerImpeller	994	74.57	579
2.3.4	81%AFUE (C4) - ImprovedCompactCircBlowerImpeller + ECM	1,005	75.40	489
3.1	82%AFUE (A) - Increased HX Area	1,007	75.49	709
3.1.1	82%AFUE (A1) - ImprovedCircBlowerMotor(PSC)	1,008	75.56	692
3.1.2	82%AFUE (A2) - ImprovedCircBlowerMotor(ECM)	1,013	75.96	597
3.1.3	82%AFUE (A3) - ImprovedCircBlowerMotor(SR)	1,011	75.81	634

Maintenance Costs and Energy Prices

	A	B	K	L	M	N	O
1	NON-WEATHERIZED GAS FURNACE						
2					Energy Use Data		
3							
4				Maint.	BOH	Fuel	Electric
5	ID	Efficiency Levels & Design Options		$	*hr*	*MBtu/yr*	*kWh/year*
6	0	78%AFUE - Baseline Non-Weatherized		$36.61	792	59.42	558
36	2.3	81%AFUE (C) - Modulation (2-stage)		$36.61	985	73.85	656
37	2.3.1	81%AFUE (C1) - ImprovedCircBlowerMotor(PSC)		$36.61	987	73.99	640

Sources: Maintenance cost is based on information from GRI, MHI and PNNL. The residential energy prices are based on EIA Annual Energy Outlook (AEO) 2003 data.

Rebuttable Payback

	A	B	O	P	Q
1	**NON-WEATHERIZED GAS FURNACE**				
2			**Summary Economics**		
3			**Total Costs**		
4			**Total Installed**	**Total Operating**	**Simple Payback**
5	**ID**	**Efficiency Levels & Design Options**	*$*	*$/yr*	*years*
6	**0**	**78%AFUE - Baseline Non-Weatherized**	**$1,792**	**$495**	
7	**1.1**	**80%AFUE (A) - Increased HXArea**	**$1,802**	**$483**	**1.0**
8	**1.1.1**	80%AFUE (A1) - ImprovedCircBlowerMotor (PSC)	$1,809	$483	1.4
9	**1.1.2**	80%AFUE (A2) - ImprovedCircBlowerMotor(ECM)	$2,016	$479	14.7
10	**1.1.3**	80%AFUE (A3) - ImprovedCircBlowerMotor(SR)	$2,016	$481	16.1
11	**1.1.4**	80%AFUE (A4) - ImprovedCircBlowerImpeller w/ PSC	$1,965	$480	12.2
12	**1.1.5**	80%AFUE (A5) - ImprovedCompactCircBlowerImpeller + ECM	$2,060	$477	15.1
13	**1.2**	**80%AFUE (B) - Improved Heat Transfer Coef**	**$1,812**	**$483**	**1.8**
14	**1.2.1**	80%AFUE (B1) - ImprovedCircBlowerMotor(PSC)	$1,818	$483	2.3
15	**1.2.2**	80%AFUE (B2) - ImprovedCircBlowerMotor(ECM)	$2,025	$479	15.3
16	**1.2.3**	80%AFUE (B3) - ImprovedCircBlowerMotor(SR)	$2,025	$481	16.8
17	**1.2.4**	80%AFUE (B4) - ImprovedCircBlowerImpeller w/ PSC	$1,975	$480	12.9
18	**1.2.5**	80%AFUE (B5) - ImprovedCompactCircBlowerImpeller + ECM	$2,070	$477	15.7
19	**1.3**	**80%AFUE (C) - Modulation (2-stage)**	**$1,848**	**$472**	**2.5**
20	**1.3.1**	80%AFUE (C1) - ImprovedCircBlowerMotor(PSC)	$1,854	$472	2.7
21	**1.3.2**	80%AFUE (C2) - ImprovedCircBlowerMotor(ECM)	$2,061	$470	11.1
22	**1.3.3**	80%AFUE (C3) - ImprovedCircBlowerImpeller	$2,052	$471	10.9
23	**1.3.4**	80%AFUE (C4) - ImprovedCompactCircBlowerImpeller + ECM	$2,183	$469	15.4
24	**2.1**	**81%AFUE (A) - Increased HX Area**	**$1,888**	**$478**	**5.9**
25	**2.1.1**	81%AFUE (A1) - ImprovedCircBlowerMotor(PSC)	$1,894	$478	6.0
26	**2.1.2**	81%AFUE (A2) - ImprovedCircBlowerMotor(ECM)	$2,101	$474	15.1
27	**2.1.3**	81%AFUE (A3) - ImprovedCircBlowerMotor(SR)	$2,101	$475	16.1
28	**2.1.4**	81%AFUE (A4) - ImprovedCircBlowerImpeller w/ PSC	$2,050	$475	13.3
29	**2.1.5**	81%AFUE (A5) - ImprovedCompactCircBlowerImpeller + ECM	$2,146	$471	15.4
30					

1 Rulemaking Overview

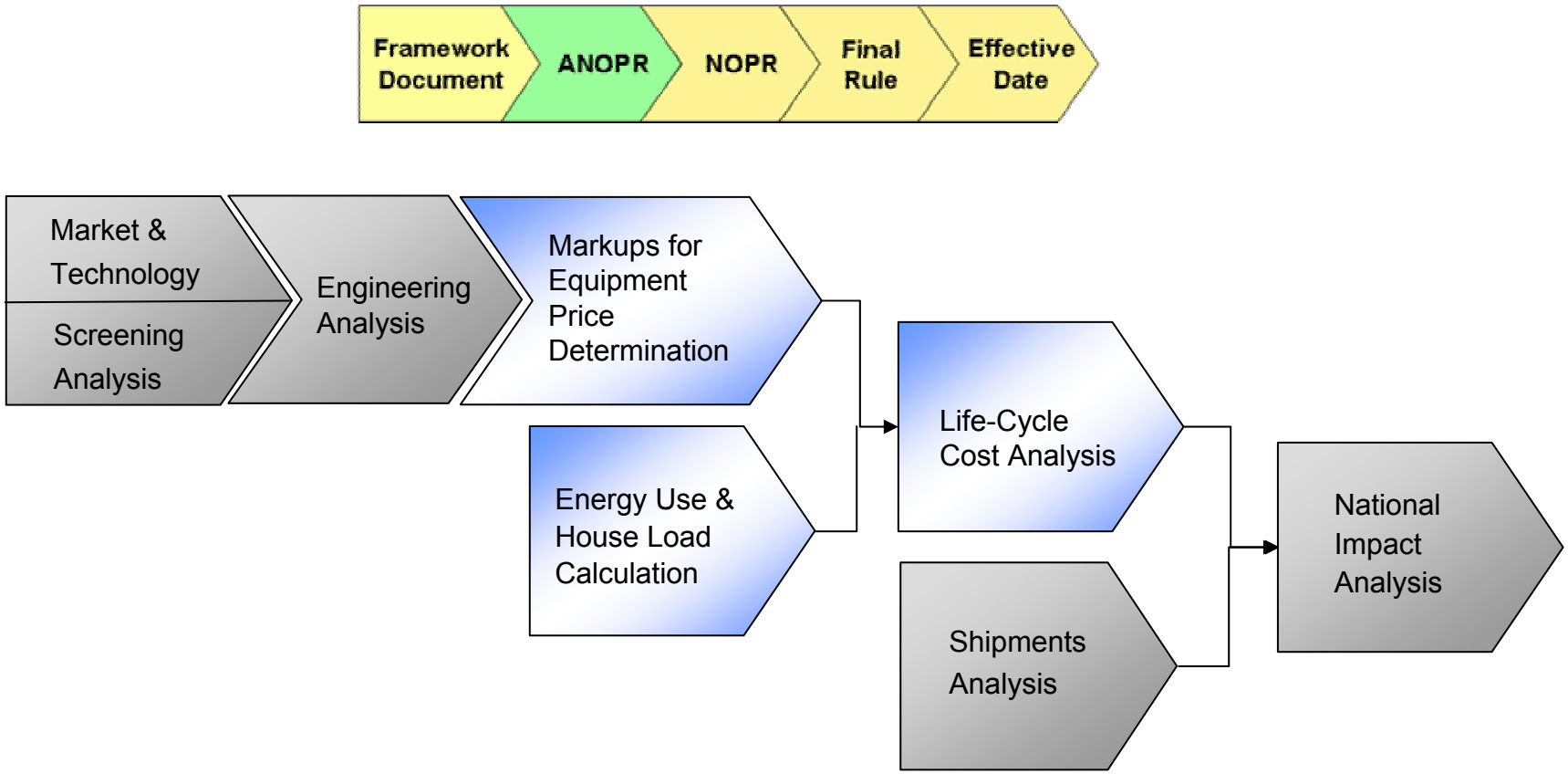
2 Engineering Analysis

3 Life-Cycle Cost Analysis

4 National Impact Analysis

Furnace/Boiler ANOPR Analysis Outline

- This presentation is focused on the Life-Cycle Cost (LCC) Analysis of the Furnace/Boiler ANOPR.



Statutory Requirements

LCC Analysis satisfies a statutory requirement:

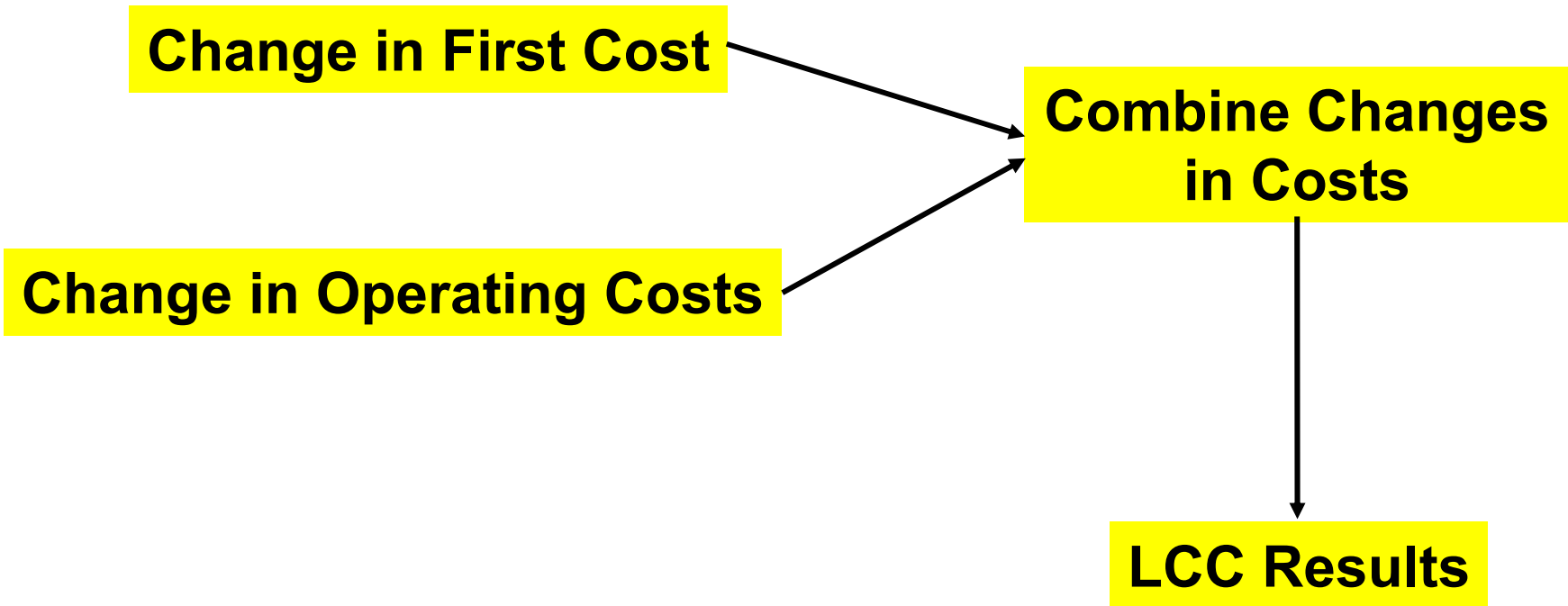
"(i) In determining whether a standard is economically justified, the Secretary shall … determine whether the benefits of standard exceed its burden by … considering

(ii) the savings in operating costs throughout the estimated average life of the covered product in the type compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered products which are likely to result from the imposition of the standard;"*

*per (42 U.S.C. 6295 (l)(2)(B)(i)(II)) Part B of Title III of the Energy Policy and Conservation Act (EPCA), Public Law 94–163—as amended by the National Appliance Energy Conservation Act (NAECA) of 1987

Basic LCC Process

Economic evaluation from the customer perspective



Basic LCC Process

- LCC equals first cost plus the sum of operating costs discounted to a particular base year
- Implemented in an Excel® spreadsheet
- Key sensitivities can be tested
- Results are expressed as LCC difference (baseline minus candidate standard)
- One LCC spreadsheet for each product class

LCC Formula

Life-Cycle Cost is expressed as the First Cost plus the sum of the discounted Operating Cost.

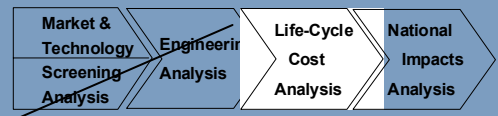
Life-Cycle Cost = First Cost

+ sum of discounted Operating Cost

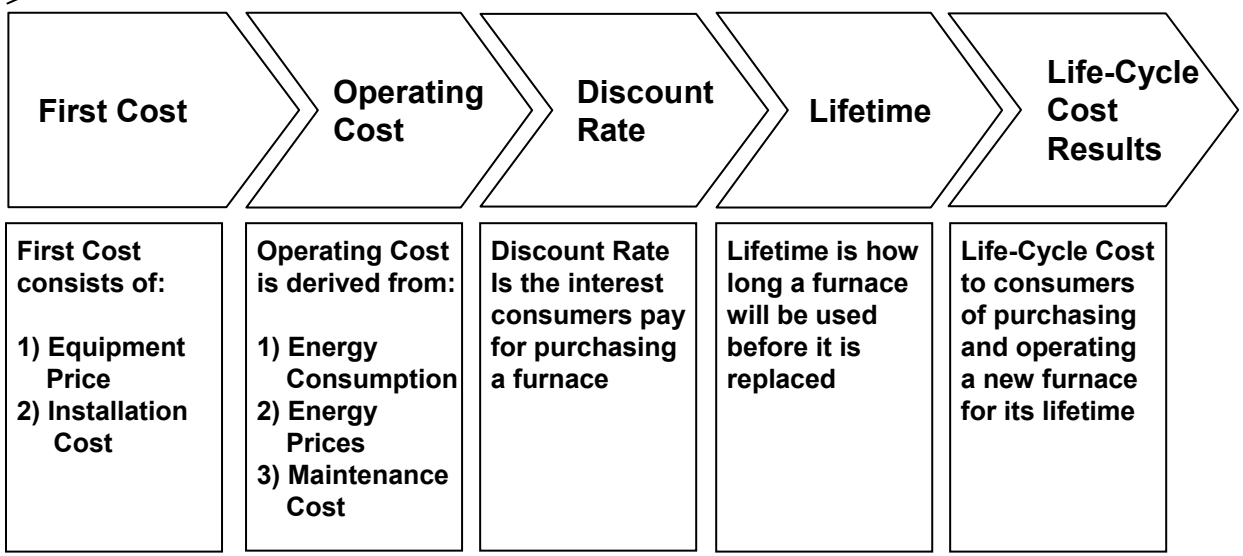
$$LCC = FirstCost + \sum_{year}^{lifetime} \frac{OperatingCost}{(1 + DiscountRate)^{year}}$$

Uncertainty and Variability

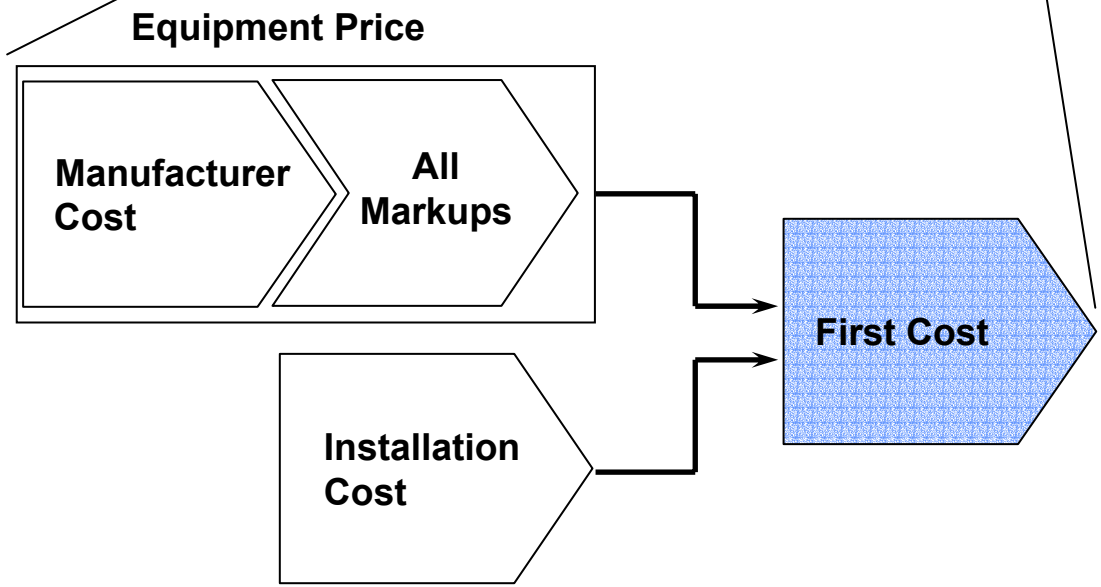
- **LCC calculation done for a representative sample of houses**
- **Monte Carlo analysis to capture uncertainty and variability**
  - Inputs sampled from probability distributions of values
  - 10,000 iterations
  - Range of LCC results
- **Identify the percentage of consumers with LCC savings due to possible standard levels**

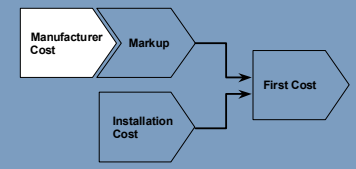


Components of the LCC Analysis



Elements of First Cost

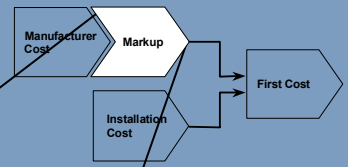




Manufacturer Costs

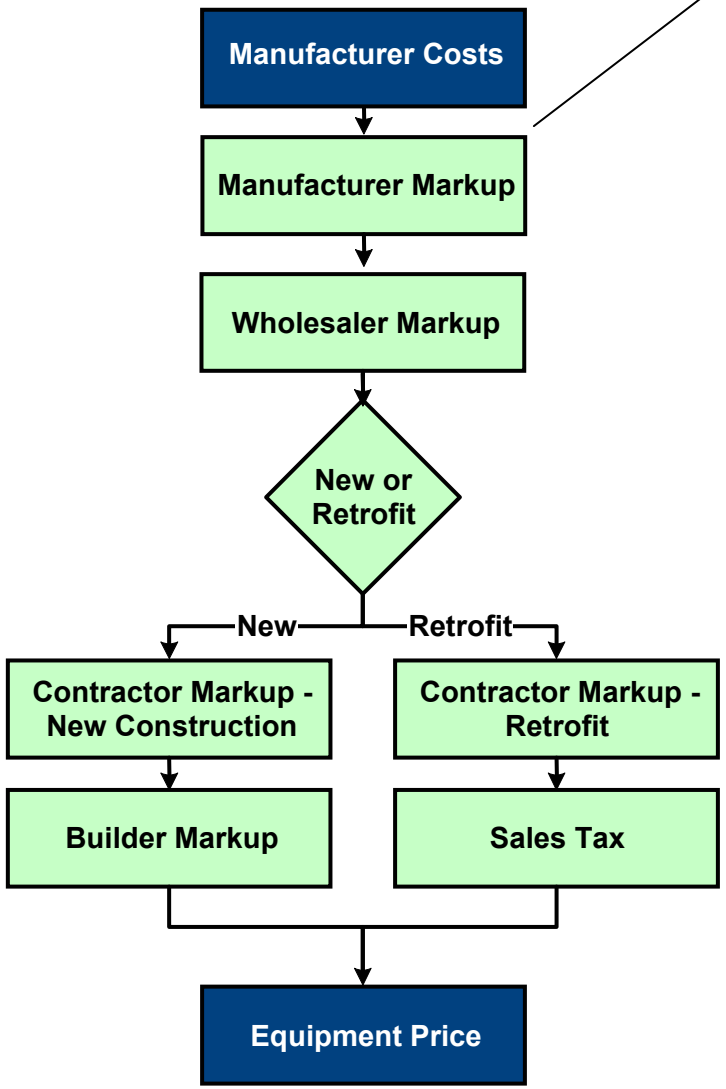
Cost of Virtual Models varies by Input Capacity and Airflow Capacity ($)

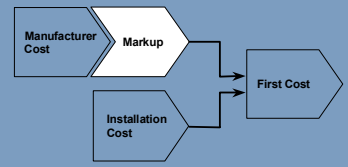
Max. Airflow (at 0.5 in.w.g. ESP)	Input Capacity (kBTUH)												Blower Cost Adders
	45	50	60	70	75	80	90	100	115	120	125	140	
800 CFM (2 tons)	307	311	320										-$9.97
1200 CFM (3 tons)	317	321	329	338	341	346	357	367					$0.00
1600 CFM (4 tons)				344	348	352	362	373	388	393	398		$5.79
2000 CFM (5 tons)							372	381	397	402	407	422	$14.82
Cost Scalars	0.93	0.94	0.96	0.99	1	1.01	1.04	1.04	1.12	1.15	1.13	1.19	



Markup

Markups across the distribution chain.





Baseline and Incremental Markups for Wholesalers and Contractors

Baseline markups are the ratio of price to cost prior to standards. The price covers all of a Wholesaler's or Contractor's expenses plus profit, direct labor and overhead costs

Incremental markups are the ratio of the additional price after standards to the additional cost due to standards.

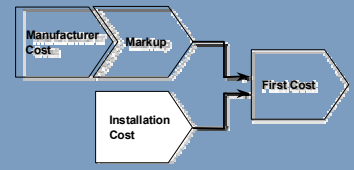
Markups for Wholesalers

BASELINE

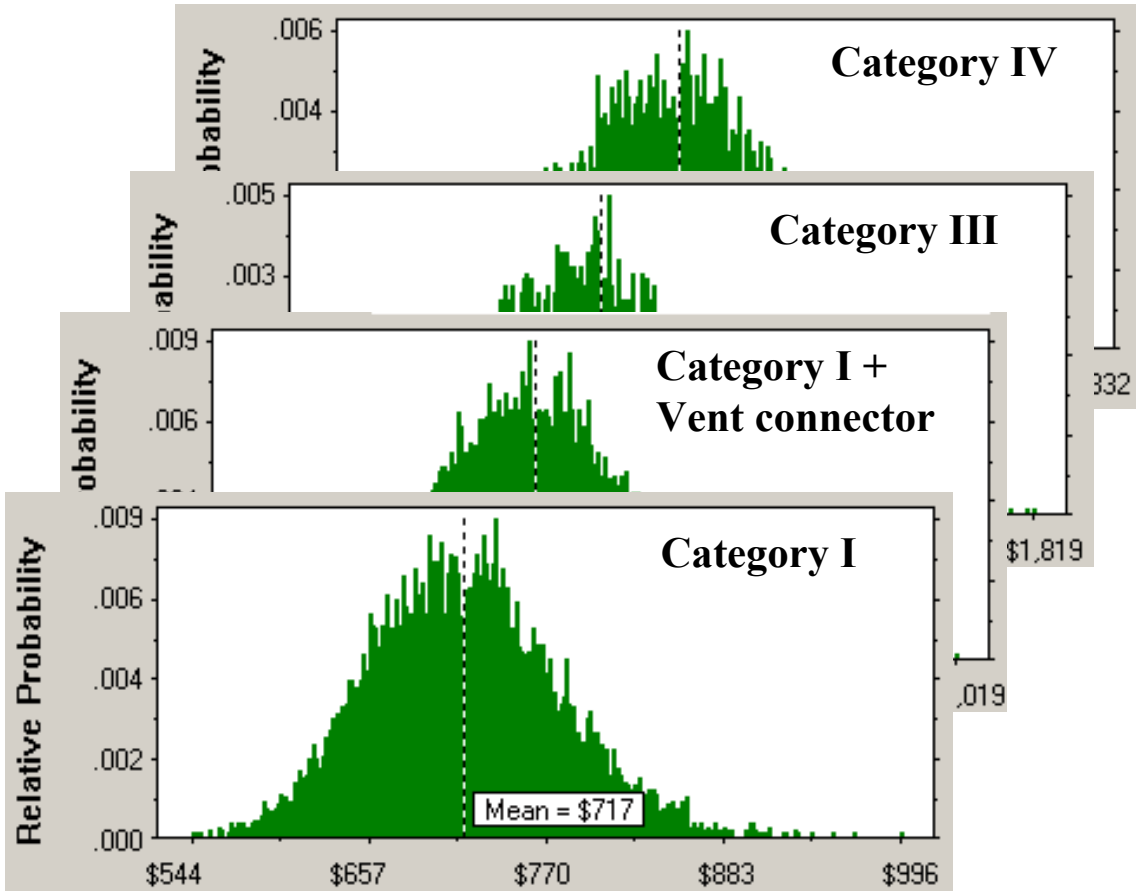
For baseline conditions	
Per Dollar Cost of Goods Sold	$1.00
Labor Expenses	*$0.25*
Other Expenses	*$0.11*
Baseline Markup =	1.36

INCREMENTAL

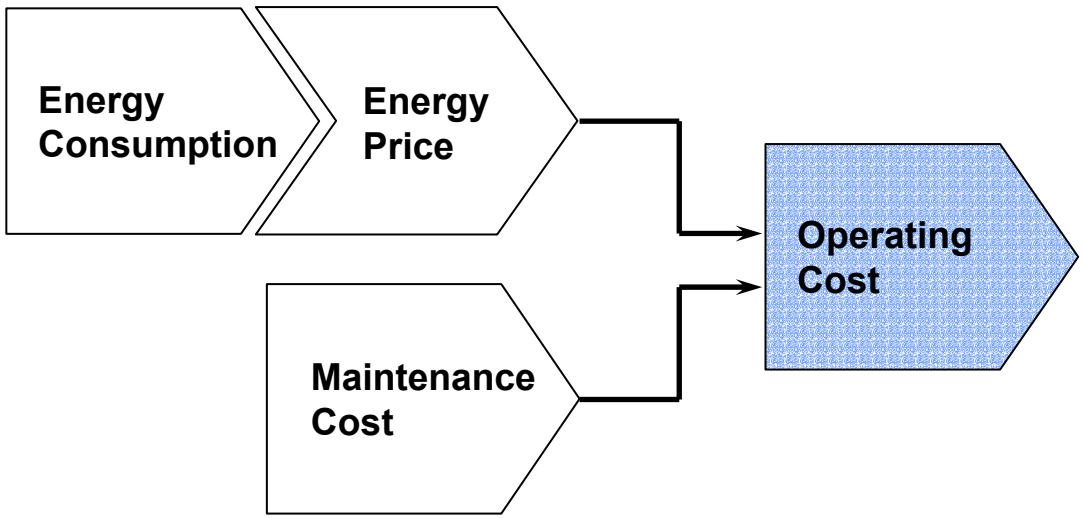
For an incremental change in CGS	
Per Dollar Cost of Goods Sold	$1.00
~~*Labor Expenses*~~	~~*$0.25*~~
Other Expenses	*$0.11*
Incremental Markup =	1.11

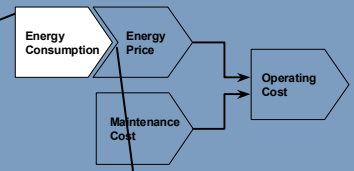


Installation Cost

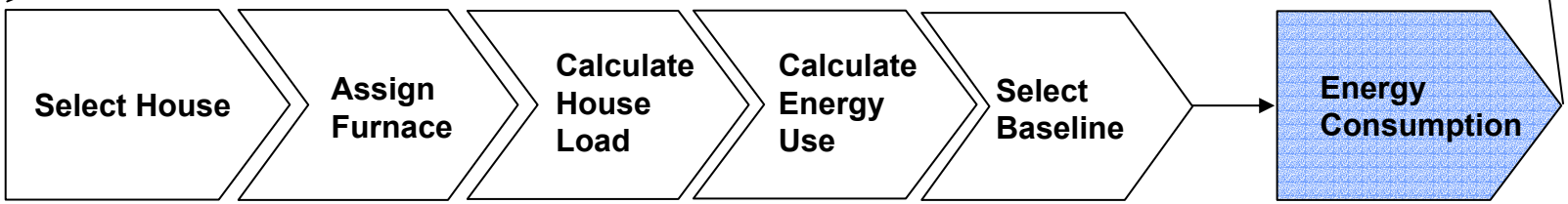


Elements of Operating Cost



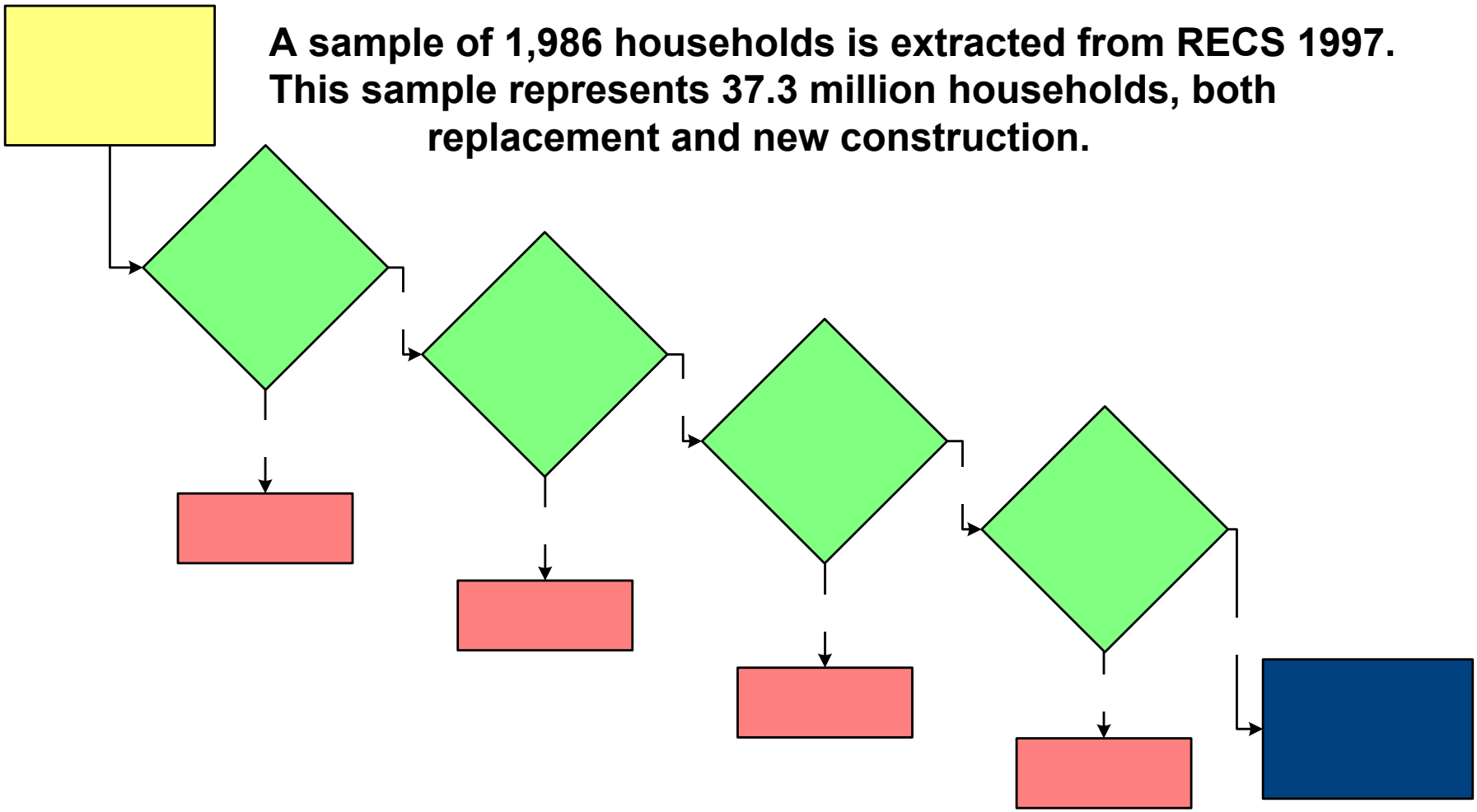


Energy Consumption



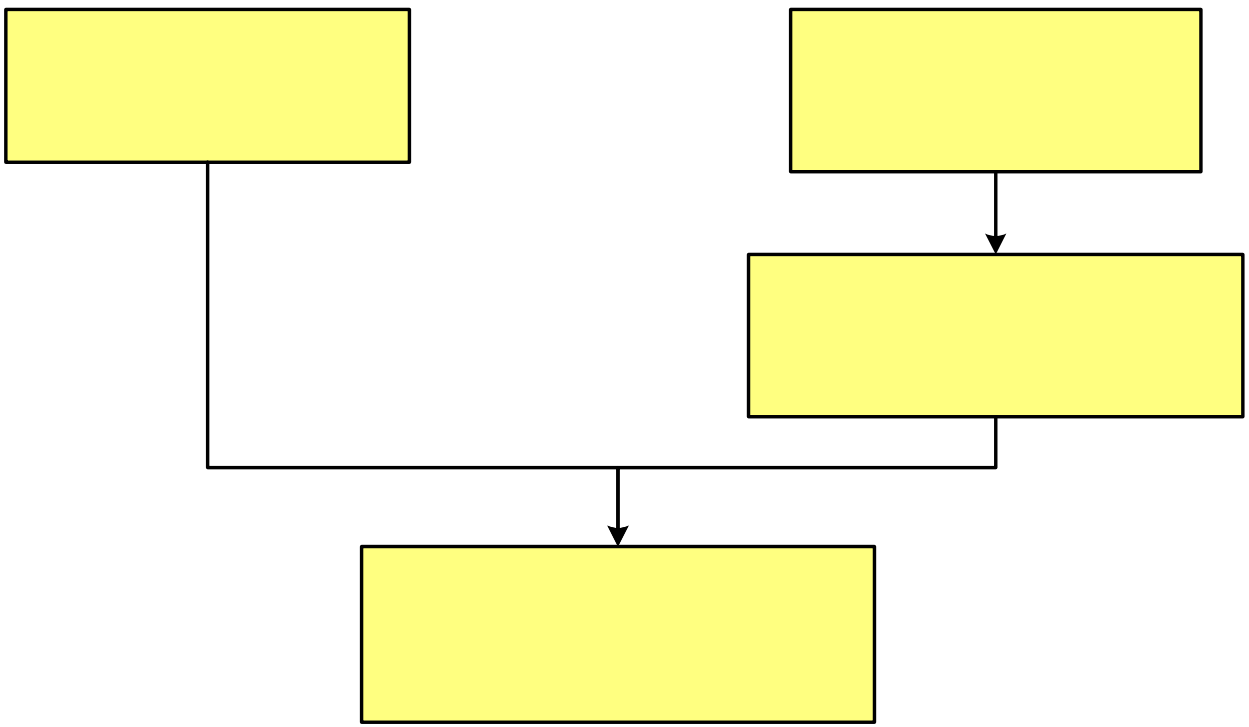
Selection of Houses

A sample of 1,986 households is extracted from RECS 1997. This sample represents 37.3 million households, both replacement and new construction.

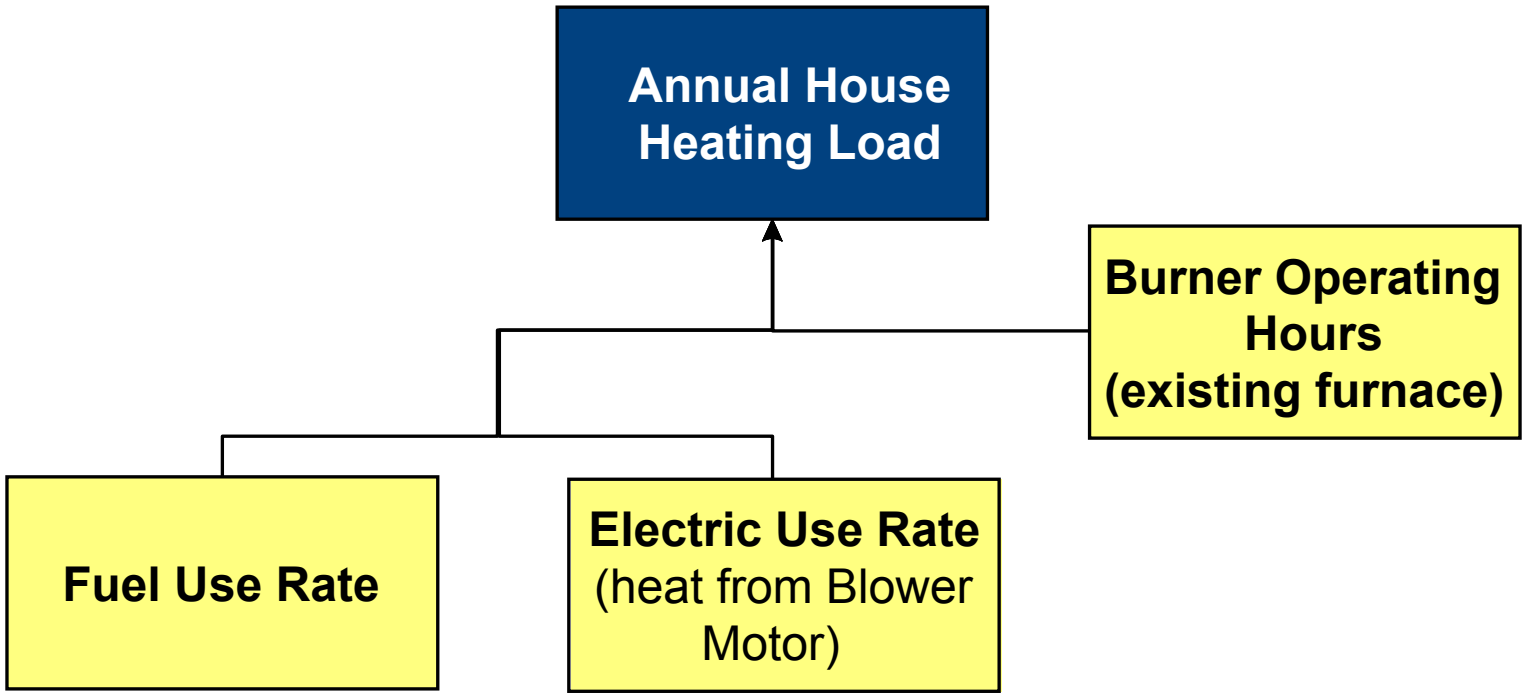


Assign Furnace

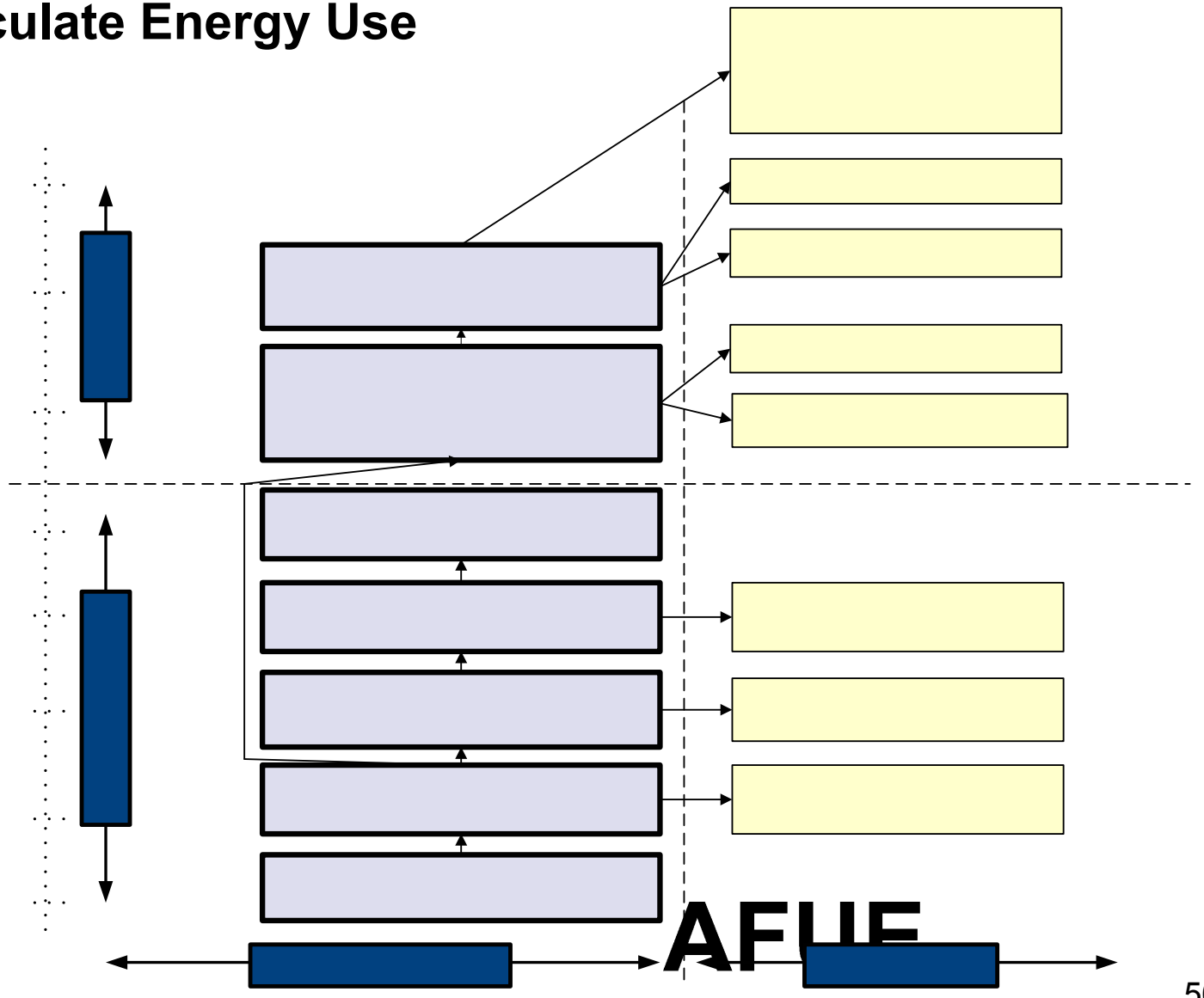
- Input capacity **correlated to** size of house
- Airflow capacity **correlated to** size of house
- AFUE for existing furnace is **correlated to** climate of house



Calculate Heating Load

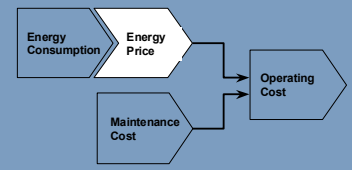


Calculate Energy Use



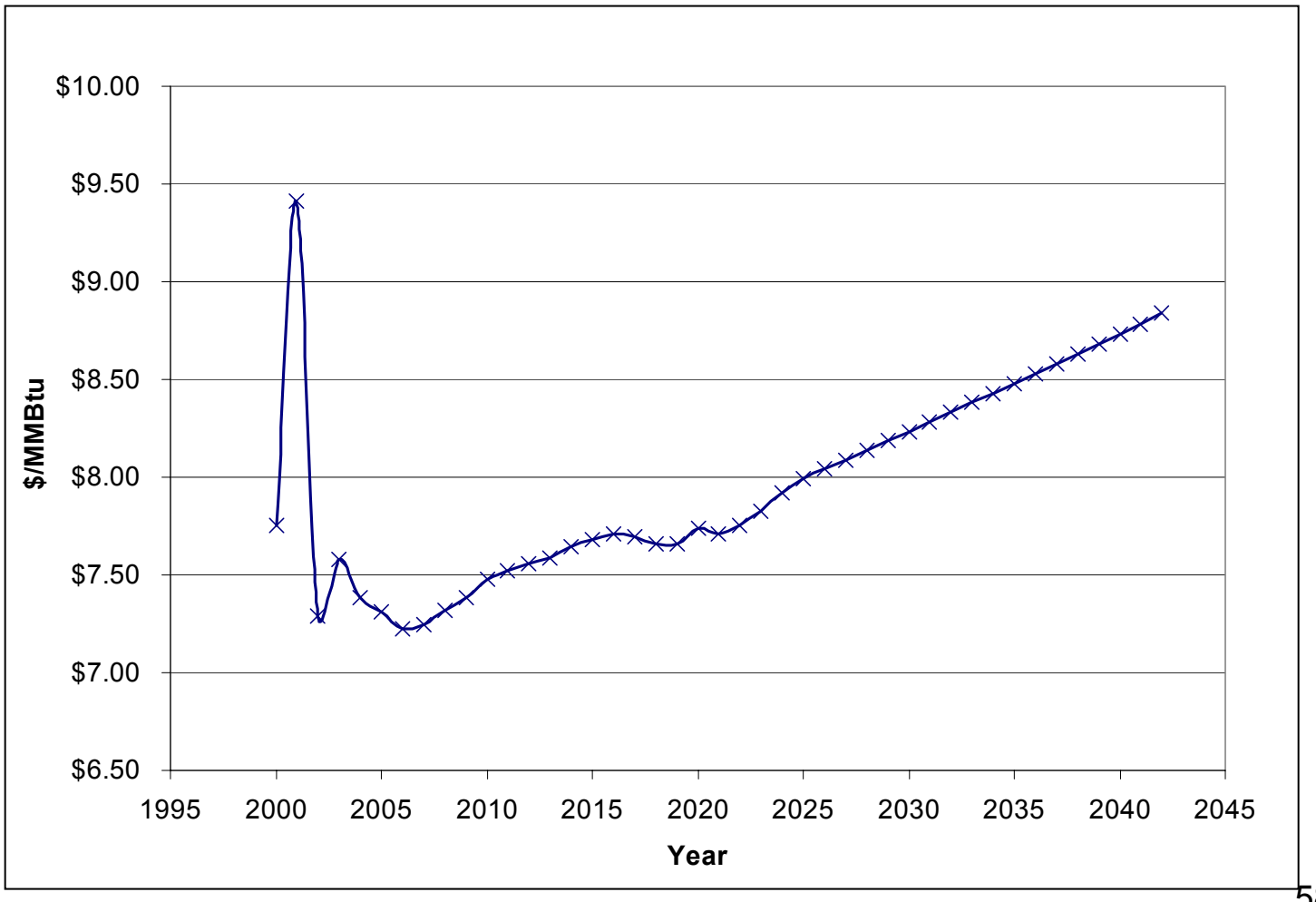
Select Baseline

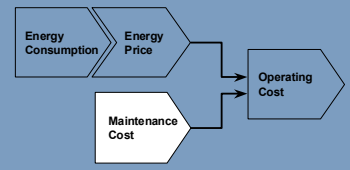
- Baseline furnace efficiency varies from house to house.
- Assign AFUE as a function of climate of sample house
  - Use same approach as for existing furnace
  - Except that:
    - AFUE distributions are from current GAMA shipment data
    - AFUE assignment is done according census division



Energy Price

Average residential price of natural gas is expected to increase (AEO 2003).





Maintenance Cost

Maintenance cost is the annual cost of maintaining a furnace in proper working condition.

AFUE	Mean
81% and less	$35 (±15%)
82-83%	$58 (±15%)
90% and 92%	$61 (±15%)
96%	$102 (±15%)

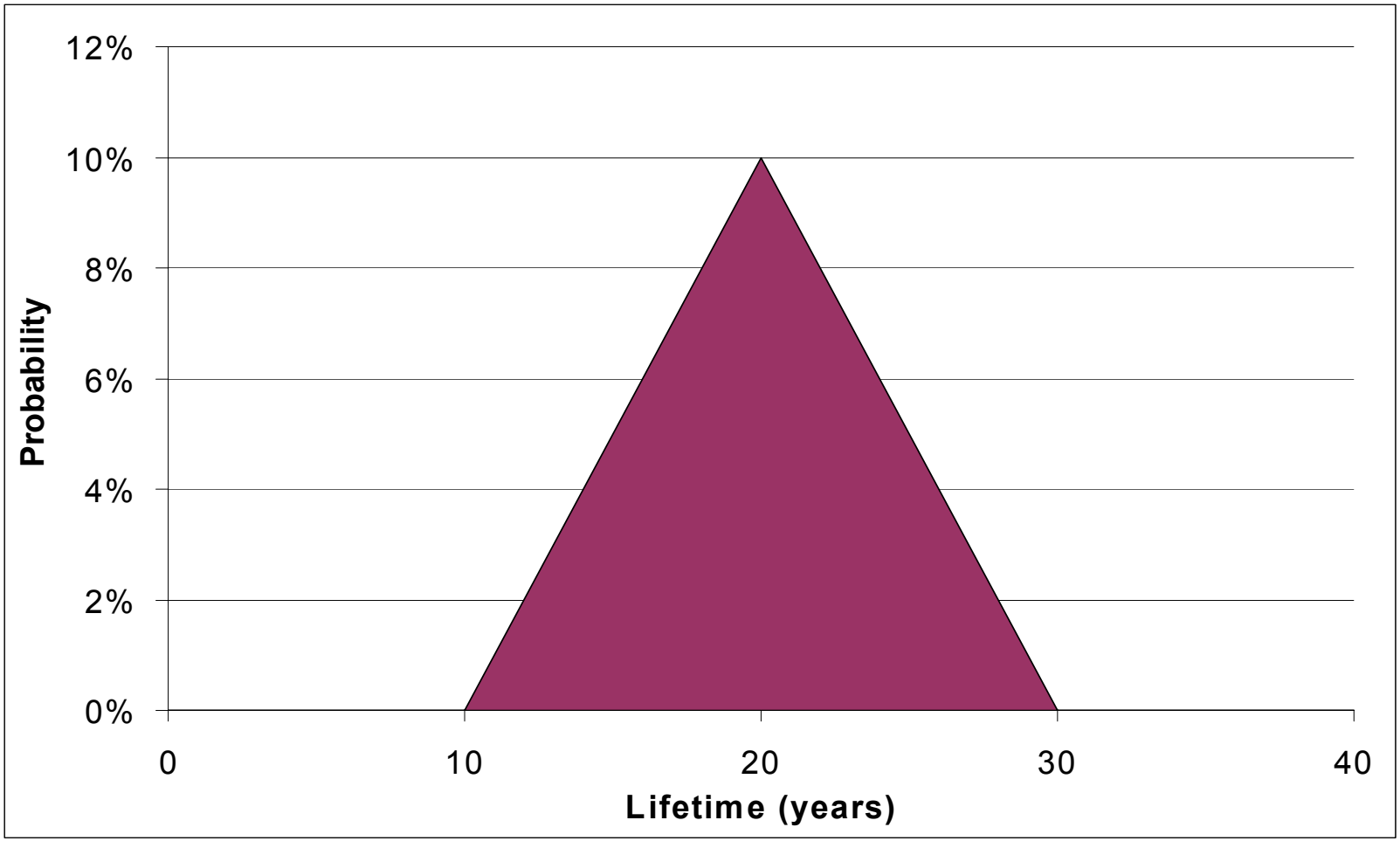
Discount Rate

Rates for Household Debt and Equity Types

Type	Average Share of Household Debt plus Equity (%)	Rate Mean (%)
Second mortgage	3	5.9
Credit card and installment	9.1	12
Transaction (checking) accounts	20	2
CD (6-month)	7.9	2.8
Savings bonds (Treasury)	1.6	3.7
Bonds (Corporate AAA)	8.3	4.4
Stocks (S&P500)	30.2	9.6
Mutual funds	19.8	7.6
Total/Weighted-average discount rate	**100**	**6.7**

New construction	**100**	**7**

Furnace Lifetimes



Source: Appliance Magazine, Sept. 2001.

GAS FURNACE (NON-WEATHERIZED)

USER OPTIONS:

Installation Scenario
- ○ GRI Data
- ○ NR Canada Data
- ◉ Installation Model

Energy Price Trend: AEO 2003 - Reference Case

Start Year: 2012

ASSUMPTIONS:

Lifetime	20.0	years
Discount Rate	5.9%	

HOUSEHOLD INFORMATION (EXISTING):

RECS ID: 1918

Input Capacity	80	kBtu/hr
Air Handler Size	1200	CFM
AFUE of Existing Unit	80%	
Annual Furnace Gas Use	13.18	MMBtu
House Heating Load	15.72	MMBtu
AC Operating Hours	441	hour
Heating Fuel	2	(1=Gas,2=LPG)

1997 Energy Prices for Household (in 2001 dollars)

	Average	Marginal	
LPG Price (annual)	$8.13	$8.14	per MMBtu
Elec. Price (winter)	$0.14	$0.14	per kWh
Elec. Price (summer)	$0.14	$0.15	per kWh

*Average prices are annual average prices
*All costs in 2001 dollars

LIFE CYCLE COST CALCULATION

LIFE CYCLE COSTS RESULTS:

Year of Purchase	2012
Year Equipment Retires	2031

Energy Price used in LCC (in 2001 dollars)	Average 2012	Average 2031	Marginal 2012	Marginal 2031
Gas Price - winter ($/MMBtu)	8.44	9.17	8.45	9.18
Elec. Price - winter ($/kWh)	0.12	0.13	0.12	0.13
Elec. Price - summer ($/kWh)	0.12	0.13	0.13	0.13

Baseline Efficiency Level: 1 — 80% AFUE

	Eff. Level	Description	AFUE	Burner Oper. Hours High (hours)	Burner Oper. Hours Reduced (hours)	AC Oper. Hours (hours)	Annual Energy Use LPG ($/MMBtu)	Electricity Winter ($/kWh)	Electricity Winter (¢/1000CFM)	Electricity Summer ($/kWh)	Electricity Summer (¢/1000CFM)	Markup	
	0	78% AFUE - NAECA Min.	78%	245	0	441	13.6	145.5	327	194.1	383	289%	$
Baseline	1	80% AFUE - Incr. HX Area	80%	239	0	441	13.1	142.0	327	194.1	383	288%	$
	2	80% AFUE - PSC+	80%	239	0	440	13.1	137.0	311	184.5	365	287%	$
	3	80% AFUE - ECM	80%	242	0	437	13.3	93.8	186	146.0	279	267%	$
	4	80% AFUE - BC/ECM+	80%	243	0	432	13.4	72.4	118	96.0	185	265%	$
	5	80% 2-stage Mod	80%	28	299	441	18.7	155.4	327	194.1	383	282%	$
	6	80% 2-stage Mod ECM	80%	29	305	437	13.1	77.5	186	146.0	279	263%	$
	7	80% 2-stage Mod BC/ECM+	80%	29	307	432	13.3	60.8	118	96.0	185	262%	$
	8	81% AFUE - Incr. HX Area	81%	236	0	441	18.9	140.3	327	194.1	383	287%	$
	9	81% AFUE - PSC+	81%	236	0	440	18.9	135.3	311	184.5	365	286%	$
	10	81% AFUE - ECM	81%	239	0	437	13.1	92.7	186	146.0	279	266%	$
	11	81% AFUE - BC/ECM+	81%	240	0	432	13.2	71.5	118	96.0	185	265%	$
	12	81% 2-stage Mod	81%	28	295	441	18.5	153.6	327	194.1	383	281%	$
	13	81% 2-stage Mod ECM	81%	28	301	437	18.9	76.6	186	146.0	279	263%	$
	14	81% 2-stage Mod BC/ECM+	81%	29	304	432	19.0	60.0	118	96.0	185	261%	$
	15	82% AFUE - Incr. HX Area	82%	233	0	441	18.7	138.6	327	194.1	383	286%	$
	16	82% AFUE - PSC+	82%	234	0	440	18.7	133.7	311	184.5	365	285%	$
	17	82% AFUE - ECM	82%	236	0	437	18.9	91.6	186	146.0	279	266%	$
	18	82% AFUE - BC/ECM+	82%	237	0	432	18.9	70.6	118	96.0	185	264%	$
	19	82% 2-stage Mod	82%	27	292	441	18.3	151.8	327	194.1	383	280%	$
	20	82% 2-stage Mod ECM	82%	28	297	437	18.7	75.7	186	146.0	279	262%	$
	21	82% 2-stage Mod BC/ECM+	82%	28	300	432	18.8	59.3	118	96.0	185	261%	$
	22	83% AFUE - Incr. HX Area	83%	231	0	441	18.4	137.0	327	194.1	383	285%	$
	23	90% AFUE	90%	213	0	441	17.1	125.1	310	195.4	386	253%	$
	24	90% AFUE - PSC+	90%	214	0	440	17.1	120.9	296	185.7	367	253%	$
	25	90% AFUE - ECM	90%	215	0	437	17.2	86.8	186	146.0	279	248%	$
	26	90% AFUE - BC/ECM+	90%	216	0	432	17.3	67.7	118	96.0	185	247%	$
	27	91% 2-stage Mod ECM	91%	15	292	437	16.9	75.1	186	146.0	279	246%	$
	28	91% 2-stage BC/ECM+	91%	15	295	432	17.0	60.0	118	96.0	185	245%	$
	29	91% Step Mod ECM	91%	15	290	437	16.7	74.6	186	146.0	279	237%	$
	30	91% Step Mod BC/ECM+	91%	15	293	432	16.9	59.7	118	96.0	185	237%	$
	31	92%AFUE - Incr. HX Area	92%	209	0	441	16.7	122.5	310	195.4	386	251%	$
	32	92% AFUE - PSC+	92%	209	0	440	16.7	118.3	296	185.7	367	251%	$
	33	92% AFUE - ECM	92%	211	0	437	16.8	85.0	186	146.0	279	242%	$
	34	92% AFUE - BC/ECM+	92%	211	0	432	16.9	66.3	118	96.0	185	242%	$
	35	93% 2-stage Mod ECM	93%	14	286	437	16.5	73.6	186	146.0	279	241%	$
	36	93% 2-stage Mod BC/ECM+	93%	15	289	432	16.6	58.7	118	96.0	185	240%	$
	37	93% Step Mod ECM	93%	14	284	437	16.4	73.0	186	146.0	279	234%	$
	38	93% Step Mod BC/ECM+	93%	14	287	432	16.5	58.4	118	96.0	185	233%	$
	39	96% AFUE Step Mod ECM	96%	14	276	437	15.9	70.8	186	146.0	279	229%	$
	40	96% AFUE Step Mod BC/ECM+	96%	14	278	432	16.0	56.6	118	96.0	185	228%	$

File Edit View Insert Format Tools Data Window Cell Run CBTools Help Acrobat

The following is a list of the worksheets included in this LCC spreadsheet:

You can navigate to any of these worksheets by clicking on the hyperlinks.

Summary	Summary of LCC calculations
Engineering	(1) A descriptive name and the AFUE of each design option. Each design option is assigned an efficiency level (0 to 39). (2) Baseline (78% AFUE) manufacturer's cost and incremental manufacturer's costs for other design options (3) Depending on the input capacity and air handler size assigned, the manufacturer's costs are adjusted accordingly. (4) air flow efficiency η, BEh and Bec for each design option
MnfCost Adjustment	Manufacturer's cost scalars for non-condensing and condensing furnaces by input capacity and adjustments for maximum airflow capacity.
Markups	Distributions for manufacturer's markup, wholesaler's markups, contractor's markup, builder's markup and sales tax
Installation Cost	Distributions of installation costs by AFUE
Relining Cost	Distributions of Relining Cost
Maintenance Cost	Distributions of maintenance costs by AFUE
Electricity Use	Calculation of (1) household heating load HHL, (2) air flow efficiency η, BE_h and BE_c for baseline, PSC+, ECM and BC/ECM+ blower/motors.
Generic Models	Using the input capacity and A/C capacity, the household equipment is mapped to one of the 25 generic models
Fan Curves	Low and high fan curves by size of air handler (baseline design, ECM, BC/ECM+) Low and high air flow efficiency curves for non-condensing and condensing furnaces
BaselineEff by Divisio	Baseline Efficiency (ranked ordered) by percentile in each of 14 regions.
HDD Dist by Division	Distribution of HDD (ranked ordered) by percentile for households in each of 14 regions.
RECS HH Data	RECS 97 household informations for households with gas furnaces
Energy Price Trends	Energy price trends based on AEO2003
AFUE Dist	Distribution of AFUE by shipment percentile. Distribution of HDD by percentile of RECS household
SEER Dist	Distribution of centrail A/C SEER from historical shipment
Input Capacity	Distribution of input capacity by shipment percentile. Distribution of square footage by percentile of RECS household
AC Capacity	Distribution of AC capacity by shipment percentile
Discount Rate	Distribution of discount rates for new and replacement units
Lifetime	Distribution of lifetime of equipment
Labels	Labels for setting up graphical user interface

GAS FURNACE (NON-WEATHERIZED)

USER OPTIONS:

Installation Scenario
- GRI Data
- NR Canada Data
- Installation Model

Energy Price Trend: AEO 2003 - Reference Case
Start Year: 2012

ASSUMPTIONS:

Lifetime	20.0	years
Discount Rate	5.9%	

HOUSEHOLD INFORMATION (EXISTING) RECS ID: 1918

Input Capacity	80	kBtu/hr
Air Handler Size	1200	CFM
AFUE of Existing Unit	80%	
Annual Furnace Gas Use	19.18	MMBtu
House Heating Load	15.72	MMBtu
AC Operating Hours	441	hours
Heating Fuel	2	(1=Oil, 2=LPG)

1997 Energy Prices for Household (in 2001 dollars)

	Average	Marginal	
LPG Price (annual)	$8.13	$8.14	per MMBtu
Elec. Price (winter)	$0.14	$0.14	per kWh
Elec. Price (summer)	$0.14	$0.15	per kWh

*Average prices are annual average prices
*All costs in 2001 dollars

Installation Scenario
GRI Data
NR Canada Data
Installation Model

LIFE CYCLE COST CALCULATION

LIFE CYCLE COSTS RESULTS:

Year of Purchase: 2012
Year Equipment Retires: 2031

Energy Price used in LCC (in 2001 dollars)	Average 2012	Average 2031	Marginal 2012	Marginal 2031
Gas Price - winter ($/MMBtu)	8.44	9.17	8.45	9.18
Elec. Price - winter ($/kWh)	0.12	0.13	0.12	0.13
Elec. Price - summer ($/kWh)	0.12	0.13	0.13	0.13

Baseline Efficiency Level: 1 — 80% AFUE

Eff. Level	Description	AFUE	Burner Oper. Hours High (hours)	Burner Oper. Hours Reduced (hours)	AC Oper. Hours (hours)	Annual Energy Use LPG (MMBtu)	Electricity Winter (kWh)	Electricity Winter (1000CF)	Electricity Summer (kWh)	Electricity Summer (1000CFM)	Markup	R
0	78% AFUE - NAECA Min.	78%	245	0	441	19.6	145.5	327	194.1	383	289%	$
Baseline 1	80% AFUE - Incr. HX Area	80%	239	0	441	19.1	142.0	327	194.1	383	288%	$
2	80% AFUE - PSC+	80%	239	0	440	19.1	137.0	311	184.5	365	287%	$
3	80% AFUE - ECM	80%	242	0	437	19.3	93.8	186	146.0	279	267%	$
4	80% AFUE - BC/ECM+	80%	243	0	432	19.4	72.4	118	96.0	185	265%	$
5	80% 2-stage Mod	80%	28	239	441	18.7	155.4	327	194.1	383	282%	$
6	80% 2-stage Mod ECM	80%	29	305	437	19.1	77.5	186	146.0	279	263%	$
7	80% 2-stage Mod BC/ECM+	80%	29	307	432	19.3	60.8	118	96.0	185	262%	$
8	81% AFUE - Incr. HX Area	81%	236	0	441	18.9	140.3	327	194.1	383	287%	$
9	81% AFUE - PSC+	81%	236	0	440	18.9	135.3	311	184.5	365	286%	$
10	81% AFUE - ECM	81%	239	0	437	19.1	92.7	186	146.0	279	266%	$
11	81% AFUE - BC/ECM+	81%	240	0	432	19.2	71.5	118	96.0	185	265%	$
12	81% 2-stage Mod	81%	28	235	441	18.5	153.6	327	194.1	383	281%	$
13	81% 2-stage Mod ECM	81%	28	301	437	18.9	76.6	186	146.0	279	263%	$
14	81% 2-stage Mod BC/ECM+	81%	29	304	432	19.0	60.0	118	96.0	185	261%	$
15	82% AFUE - Incr. HX Area	82%	233	0	441	18.7	138.6	327	194.1	383	286%	$
16	82% AFUE - PSC+	82%	234	0	440	18.7	133.7	311	184.5	365	285%	$
17	82% AFUE - ECM	82%	236	0	437	18.9	91.6	186	146.0	279	266%	$
18	82% AFUE - BC/ECM+	82%	237	0	432	18.9	70.6	118	96.0	185	264%	$
19	82% 2-stage Mod	82%	27	232	441	18.3	151.8	327	194.1	383	280%	$
20	82% 2-stage Mod ECM	82%	28	297	437	18.7	75.7	186	146.0	279	262%	$
21	82% 2-stage Mod BC/ECM+	82%	28	300	432	18.8	59.3	118	96.0	185	261%	$
22	83% AFUE - Incr. HX Area	83%	231	0	441	18.4	137.0	327	194.1	383	285%	$
23	90% AFUE	90%	213	0	441	17.1	125.1	310	195.4	386	259%	$
24	90% AFUE - PSC+	90%	214	0	440	17.1	120.9	296	185.7	367	259%	$
25	90% AFUE - ECM	90%	215	0	437	17.2	86.8	186	146.0	279	248%	$
26	90% AFUE - BC/ECM+	90%	216	0	432	17.3	67.7	118	96.0	185	247%	$
27	91% 2-stage Mod ECM	91%	15	232	437	16.9	75.1	186	146.0	279	246%	$
28	91% 2-stage BC/ECM+	91%	15	235	432	17.0	60.0	118	96.0	185	245%	$
29	91% Step Mod ECM	91%	15	230	437	16.7	74.6	186	146.0	279	237%	$
30	91% Step Mod BC/ECM+	91%	15	233	432	16.9	59.7	118	96.0	185	237%	$
31	92%AFUE - Incr. HX Area	92%	209	0	441	16.7	122.5	310	195.4	386	251%	$
32	92% AFUE - PSC+	92%	209	0	440	16.7	118.3	296	185.7	367	251%	$
33	92% AFUE - ECM	92%	211	0	437	16.8	85.0	186	146.0	279	242%	$
34	92% AFUE - BC/ECM+	92%	211	0	432	16.9	66.3	118	96.0	185	242%	$
35	93% 2-stage Mod ECM	93%	14	286	437	16.5	73.6	186	146.0	279	241%	$
36	93% 2-stage Mod BC/ECM+	93%	15	289	432	16.6	58.7	118	96.0	185	240%	$
37	93% Step Mod ECM	93%	14	284	437	16.4	73.0	186	146.0	279	234%	$
38	93% Step Mod BC/ECM+	93%	14	287	432	16.5	58.4	118	96.0	185	233%	$
39	96% AFUE Step Mod ECM	96%	14	276	437	15.9	70.8	186	146.0	279	229%	$
40	96% AFUE Step Mod BC/ECM+	96%	14	278	432	16.0	56.6	118	96.0	185	228%	$

GAS FURNACE (NON-WEATHERIZED)

USER OPTIONS:

Installation Scenario

- ○ GRI Data
- ○ NR Canada Data
- ◉ Installation Model

Energy Price Trend AEO 2003 - Reference Case

Start Year 2012

ASSUMPTIONS:

Lifetime	**20.0**	*years*
Discount Rate	**5.92**	

HOUSEHOLD INFORMATION (EXISTING):

RECS ID: 1918

Input Capacity	**80**	*kBtu/hr*
Air Handler Size	**1200**	*CFM*
AFUE of Existing Unit	**80%**	
Annual Furnace Gas Use	**19.18**	*MMBtu*
House Heating Load	**15.72**	*MMBtu*
AC Operating Hours	**441**	*hour*
Heating Fuel	**2**	*(1=Gas,2=LPG)*

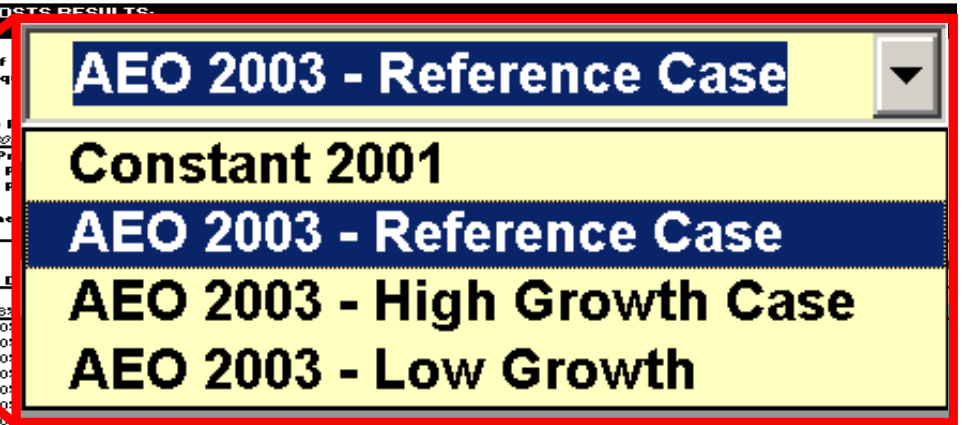
1997 Energy Prices for Household *(in 2001 dollars)*

	Average	Marginal	
LPG Price (annual)	**$8.13**	**$8.14**	*per MMBtu*
Elec. Price *(winter)*	**$0.14**	**$0.14**	*per kWh*
Elec. Price *(summer)*	**$0.14**	**$0.15**	*per kWh*

**Average prices are annual average prices*
**All costs in 2001 dollars*

LIFE CYCLE COST CALCULATION

LIFE CYCLE COSTS RESULTS



Eff. Level										
8	81% AFUE - Incr. HX Area	81%	236	0	441	18.9	140.3	327	194.1	383	267%
9	81% AFUE - PSC+	81%	236	0	440	18.9	135.3	311	184.5	365	266%
10	81% AFUE - ECM	81%	239	0	437	19.1	92.7	186	146.0	279	266%
11	81% AFUE - BC/ECM+	81%	240	0	432	19.2	71.5	118	96.0	185	265%
12	81% 2-stage Mod	81%	28	295	441	18.5	153.6	327	194.1	383	281%
13	81% 2-stage Mod ECM	81%	28	301	437	18.9	76.6	186	146.0	279	263%
14	81% 2-stage Mod BC/ECM+	81%	29	304	432	19.0	60.0	118	96.0	185	261%
15	82% AFUE - Incr. HX Area	82%	233	0	441	18.7	138.6	327	194.1	383	266%
16	82% AFUE - PSC+	82%	234	0	440	18.7	133.7	311	184.5	365	265%
17	82% AFUE - ECM	82%	236	0	437	18.9	91.6	186	146.0	279	266%
18	82% AFUE - BC/ECM+	82%	237	0	432	18.9	70.6	118	96.0	185	264%
19	82% 2-stage Mod	82%	27	292	441	18.3	151.8	327	194.1	383	280%
20	82% 2-stage Mod ECM	82%	28	297	437	18.7	75.7	186	146.0	279	262%
21	82% 2-stage Mod BC/ECM+	82%	28	300	432	18.8	59.3	118	96.0	185	261%
22	83% AFUE - Incr. HX Area	83%	231	0	441	18.4	137.0	327	194.1	383	265%
23	90% AFUE	90%	213	0	441	17.1	125.1	310	195.4	386	259%
24	90% AFUE - PSC+	90%	214	0	440	17.1	120.9	296	185.7	367	259%
25	90% AFUE - ECM	90%	215	0	437	17.2	86.8	186	146.0	279	248%
26	90% AFUE - BC/ECM+	90%	216	0	432	17.3	67.7	118	96.0	185	247%
27	91% 2-stage Mod ECM	91%	15	292	437	16.9	75.1	186	146.0	279	246%
28	91% 2-stage BC/ECM+	91%	15	295	432	17.0	60.0	118	96.0	185	245%
29	91% Step Mod ECM	91%	15	290	437	16.7	74.6	186	146.0	279	237%
30	91% Step Mod BC/ECM+	91%	15	293	432	16.9	59.7	118	96.0	185	237%
31	92%AFUE - Incr. HX Area	92%	209	0	441	16.7	122.5	310	195.4	386	251%
32	92% AFUE - PSC+	92%	209	0	440	16.7	118.3	296	185.7	367	251%
33	92% AFUE - ECM	92%	211	0	437	16.8	85.0	186	146.0	279	242%
34	92% AFUE - BC/ECM+	92%	211	0	432	16.9	66.3	118	96.0	185	242%
35	93% 2-stage Mod ECM	93%	14	286	437	16.5	73.6	186	146.0	279	241%
36	93% 2-stage Mod BC/ECM+	93%	15	289	432	16.6	58.7	118	96.0	185	240%
37	93% Step Mod ECM	93%	14	284	437	16.4	73.0	186	146.0	279	234%
38	93% Step Mod BC/ECM+	93%	14	287	432	16.5	58.4	118	96.0	185	233%
39	96% AFUE Step Mod ECM	96%	14	276	437	15.9	70.8	186	146.0	279	229%
40	96% AFUE Step Mod BC/ECM+	96%	14	278	432	16.0	56.6	118	96.0	185	228%

GAS FURNACE (NON-WEATHERIZED)

LIFE CYCLE COST CALCULATION

USER OPTIONS:

Installation Scenario
- GRI Data
- NR Canada Data
- Installation Model

Energy Price Trend: AEO 2003 - Reference Case

Start Year: 2012

ASSUMPTIONS:

Lifetime	20.5	years
Discount Rate	5.9%	

HOUSEHOLD INFORMATION (EXISTING): RECS ID: 1918

Input Capacity	80	kBtu/hr
Air Handler Size	1200	CFM
AFUE of Existing Unit	80%	
Annual Furnace Gas Use	1.18	MMBtu
House Heating Load	15.72	MMBtu
AC Operating Hours	441	hour
Heating Fuel	2	(1=Gas,2=LPG)

1997 Energy Prices for Household (in 2001 dollars)

	Average	Marginal	
LPG Price (annual)	$8.13	$8.14	per MMBtu
Elec. Price (winter)	$0.14	$0.14	per kWh
Elec. Price (summer)	$0.14	$0.15	per kWh

*Average prices are annual average prices
*All costs in 2001 dollars

LIFE CYCLE COSTS RESULTS:

Year of Purchase: 2012
Year Equipment Retires: 2031

Energy Price used in LCC (in 2001 dollars)	Average 2012	Average 2031	Marginal 2012	Marginal 2031
Gas Price - winter ($/MMBtu)	8.44	9.17	8.45	9.18
Elec. Price - winter ($/kWh)	0.12	0.13	0.12	0.13
Elec. Price - summer ($/kWh)	0.12	0.13	0.13	0.13

Baseline Efficiency Level: 1 — 80% AFUE

Eff. Level	Description	AFUE	Burner Oper. Hours High (hours)	Burner Oper. Hours Reduced (hours)	AC Oper. Hours (hours)	Annual Energy Use LPG (MMBtu)	Electricity Winter ($/kWh)	Electricity Winter (¢/1000CF)	Electricity Summer ($/kWh)	Electricity Summer (¢/1000CFM)	Markup
0	78% AFUE - NAECA Min.	78%	245	0	441	13.6	145.5	327	194.1	383	283%
Baseline 1	80% AFUE - Incr. HX Area	80%	239	0	441	13.1	142.0	327	194.1	383	288%
2	80% AFUE - PSC+	80%	239	0	440	13.1	137.0	311	184.5	365	287%
3	80% AFUE - ECM	80%	242	0	437	13.3	93.8	186	146.0	279	267%
4	80% AFUE - BC/ECM+	80%	243	0	432	13.4	72.4	118	96.0	185	265%
5	80% 2-stage Mod	80%	28	239	441	18.7	155.4	327	194.1	383	282%
6	80% 2-stage Mod ECM	80%	29	305	437	19.1	77.5	186	146.0	279	263%
7	80% 2-stage Mod BC/ECM+	80%	29	307	432	19.3	60.8	118	96.0	185	262%
8	81% AFUE - Incr. HX Area	81%	236	0	441	18.9	140.3	327	194.1	383	287%
9	81% AFUE - PSC+	81%	236	0	440	18.9	135.3	311	184.5	365	286%
10	81% AFUE - ECM	81%	239	0	437	19.1	92.7	186	146.0	279	266%
11	81% AFUE - BC/ECM+	81%	240	0	432	19.2	71.5	118	96.0	185	265%
12	81% 2-stage Mod	81%	28	295	441	18.5	153.6	327	194.1	383	281%
13	81% 2-stage Mod ECM	81%	28	301	437	18.9	76.6	186	146.0	279	263%
14	81% 2-stage Mod BC/ECM+	81%	29	304	432	19.0	60.0	118	96.0	185	261%
15	82% AFUE - Incr. HX Area	82%	233	0	441	18.7	138.6	327	194.1	383	286%
16	82% AFUE - PSC+	82%	234	0	440	18.7	133.7	311	184.5	365	285%
17	82% AFUE - ECM	82%	236	0	437	18.9	91.6	186	146.0	279	266%
18				0	432	18.9	70.6	118	96.0	185	264%
19			232		441	18.3	151.8	327	194.1	383	280%
20			297		437	18.7	75.7	186	146.0	279	262%
21			300		432	18.8	59.3	118	96.0	185	261%
22				0	441	18.4	137.0	327	194.1	383	285%
23				0	441	17.1	125.1	310	195.4	386	259%
24				0	440	17.1	120.9	296	185.7	367	259%
25				0	437	17.2	86.8	186	146.0	279	248%
26				0	432	17.3	67.7	118	96.0	185	247%
27			232		437	16.9	75.1	186	146.0	279	246%
28			295		432	17.0	60.0	118	96.0	185	245%
29			230		437	16.7	74.6	186	146.0	279	237%
30			233		432	16.9	59.7	118	96.0	185	237%
31				0	441	16.7	122.5	310	195.4	386	251%
32				0	440	16.7	118.3	296	185.7	367	251%
33				0	437	16.8	85.0	186	146.0	279	242%
34				0	432	16.9	66.3	118	96.0	185	242%
35			286		437	16.5	73.6	186	146.0	279	241%
36			289		432	16.6	58.7	118	96.0	185	240%
37			284		437	16.4	73.0	186	146.0	279	234%
38			287		432	16.5	58.4	118	96.0	185	233%
39			276		437	15.9	70.8	186	146.0	279	229%
40			278		432	16.0	56.6	118	96.0	185	228%

GAS FURNACE (NON-WEATHERIZED) **Simulation Results**

Samples = 10000

		LCC					Payback			
number	Design Option: AFUE/Electricity	Average	Average Savings	Net Cost	No Impact	Net Benefit	Median	Average	% no impact	% undefined
0	78% AFUE - NAECA Min.	$9,966								
1	80% AFUE - Incr. HX Area	$9,795	$0	0%	99%	1%	2.1	37.8	99%	0%
2	80% AFUE - PSC+	$9,784	$7	17%	27%	56%	5.4	5.3	27%	14%
3	80% AFUE - ECM	$9,873	-$59	60%	27%	14%	23.0	33.7	27%	1%
4	80% AFUE - BC/ECM+	$9,822	-$21	51%	27%	23%	17.2	26.3	27%	1%
5	80% 2-stage Mod	$9,718	$41	33%	27%	40%	8.6	13.5	27%	9%
6	80% 2-stage Mod ECM	$9,795	-$13	48%	27%	26%	15.4	21.1	27%	0%
7	80% 2-stage Mod BC/ECM+	$9,782	$1	45%	27%	28%	14.3	20.9	27%	0%
8	81% AFUE - Incr. HX Area	$9,789	-$3	32%	27%	41%	8.8	27.8	27%	1%
9	81% AFUE - PSC+	$9,779	$5	30%	26%	44%	8.1	21.3	26%	0%
10	81% AFUE - ECM	$9,868	-$62	51%	26%	23%	17.8	26.2	26%	0%
11	81% AFUE - BC/ECM+	$9,816	-$24	45%	26%	29%	14.8	22.9	26%	0%
12	81% 2-stage Mod	$9,680	$63	29%	26%	45%	7.6	17.0	26%	2%
13	81% 2-stage Mod ECM	$9,796	-$20	44%	26%	29%	14.4	21.1	26%	0%
14	81% 2-stage Mod BC/ECM+	$9,782	-$5	43%	26%	31%	13.7	20.5	26%	0%
15	82% AFUE - Incr. HX Area	$10,170	-$292	70%	26%	4%	28.7	84.6	26%	67%
16	82% AFUE - PSC+	$10,159	-$284	69%	26%	5%	29.2	80.6	26%	66%
17	82% AFUE - ECM	$10,249	-$351	71%	26%	3%	48.4	102.4	26%	47%
18	82% AFUE - BC/ECM+	$10,197	-$312	68%	26%	6%	34.8	80.3	26%	36%
19	82% 2-stage Mod	$10,103	-$256	65%	26%	9%	18.5	60.2	26%	53%
20	82% 2-stage Mod ECM	$10,179	-$310	67%	26%	7%	34.6	82.1	26%	33%
21	82% 2-stage Mod BC/ECM+	$10,164	-$295	65%	26%	9%	30.9	70.4	26%	28%
22	83% AFUE - Incr. HX Area	$10,400	-$468	73%	26%	1%	63.3	121.3	26%	56%
23	90% AFUE	$9,917	-$154	56%	26%	18%	17.9	42.5	26%	21%
24	90% AFUE - PSC+	$9,907	-$145	57%	15%	27%	14.3	37.9	15%	21%
26	90% AFUE - BC/ECM+	$9,957	-$180	63%	15%	22%	19.1	42.0	15%	11%
27	91% 2-stage Mod ECM	$9,898	-$141	58%	15%	26%	16.5	40.6	15%	11%
28	91% 2-stage BC/ECM+	$9,878	-$118	58%	15%	27%	16.2	37.8	15%	9%
29	91% Step Mod ECM	$10,119	-$328	67%	15%	18%	22.2	54.2	15%	10%
30	91% Step Mod BC/ECM+	$10,110	-$315	66%	15%	18%	21.6	49.2	15%	8%
31	92%AFUE - Incr. HX Area	$9,924	-$166	60%	15%	25%	16.1	41.7	15%	17%
32	92% AFUE - PSC+	$9,914	-$156	63%	2%	35%	13.2	35.8	2%	18%
33	92% AFUE - ECM	$10,015	-$255	76%	2%	22%	21.3	45.0	2%	11%
34	92% AFUE - BC/ECM+	$9,965	-$205	73%	2%	25%	19.2	39.7	2%	9%
35	93% 2-stage Mod ECM	$9,912	-$154	67%	2%	32%	15.7	39.1	2%	9%
36	93% 2-stage Mod BC/ECM+	$9,891	-$133	66%	2%	32%	15.7	35.7	2%	7%
37	93% Step Mod ECM	$10,134	-$373	78%	2%	21%	21.6	50.4	2%	8%
38	93% Step Mod BC/ECM+	$10,124	-$362	77%	2%	21%	21.4	45.1	2%	7%
39	96% AFUE Step Mod ECM	$10,724	-$954	89%	2%	9%	32.3	88.9	2%	40%
40	96% AFUE Step Mod BC/ECM+	$10,738	-$967	91%	0%	9%	32.8	83.6	0%	39%

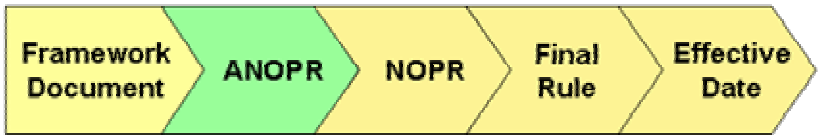
1 Rulemaking Overview

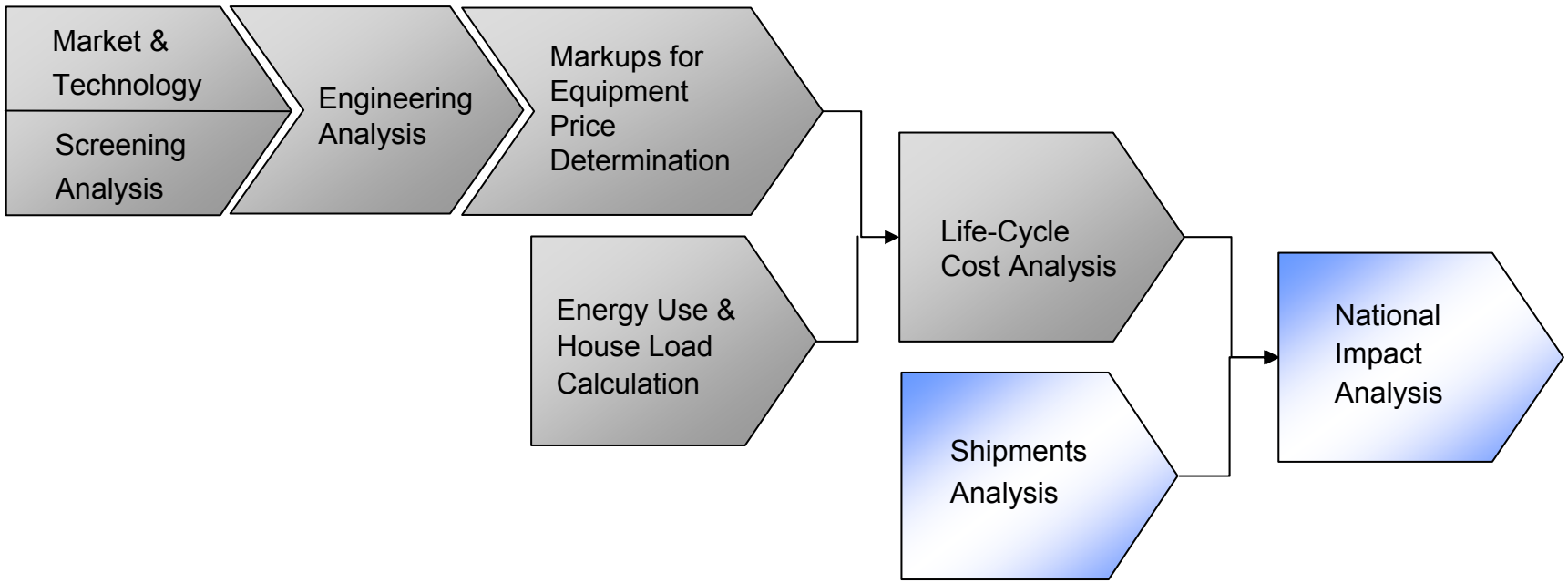
2 Engineering Analysis

3 Life-Cycle Cost Analysis

4 National Impact Analysis

ANOPR Analyses Flow Diagram





The Need for National Impact Analysis

Q. Why isn't the LCC the end of the economic analysis for the nation?

A. Specifically,

1. **LCC is performed from the perspective of households with furnaces and is not the sole expression of national impacts**
2. **Total National Energy Savings is not estimated by LCC**
3. **Manufacturers impacts are not estimated by LCC**

The Need for National Impact Analysis

Q. How does national impact analysis differ from the LCC analysis?

A. Specifically,

1. **Utilizes a shipments model to estimate the total stock of furnaces in service in any year.**
2. **Aggregates the costs and energy use, by vintage, for all years that the proposed standard is in effect.**
3. **The energy consumed at the site is not the energy consumed at the power plant or wellhead.**

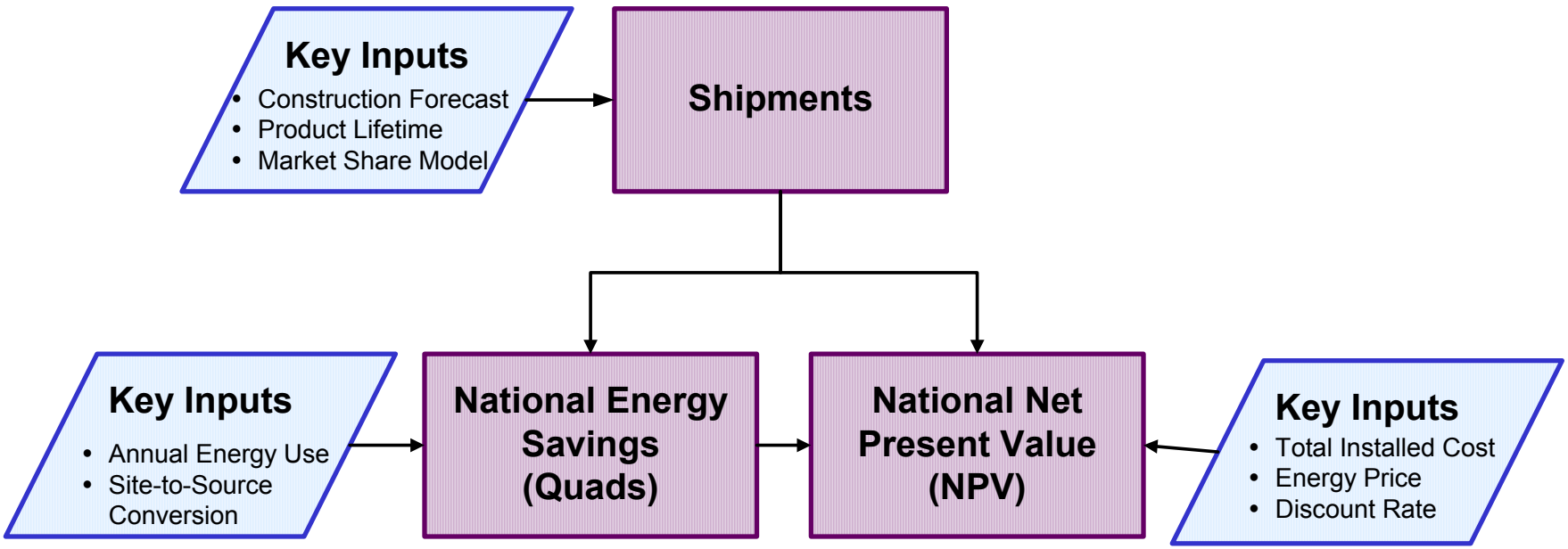
Purpose

- Estimate the National Energy Savings (NES) (Quads) by calculating annual and cumulative energy savings for the forecast period 2012-2035.
- Estimate the Net Present Value (national NPV) by calculating the impacts for equipment shipped during the period 2012-2035.

Method

- Spreadsheet-based analysis
- Utilizes energy use and installed cost from LCC analysis
- Impacts totaled for all US households with projections to the future
  - Purchases to 2035
  - Energy Impact to 2035 (source)
- Annual time series

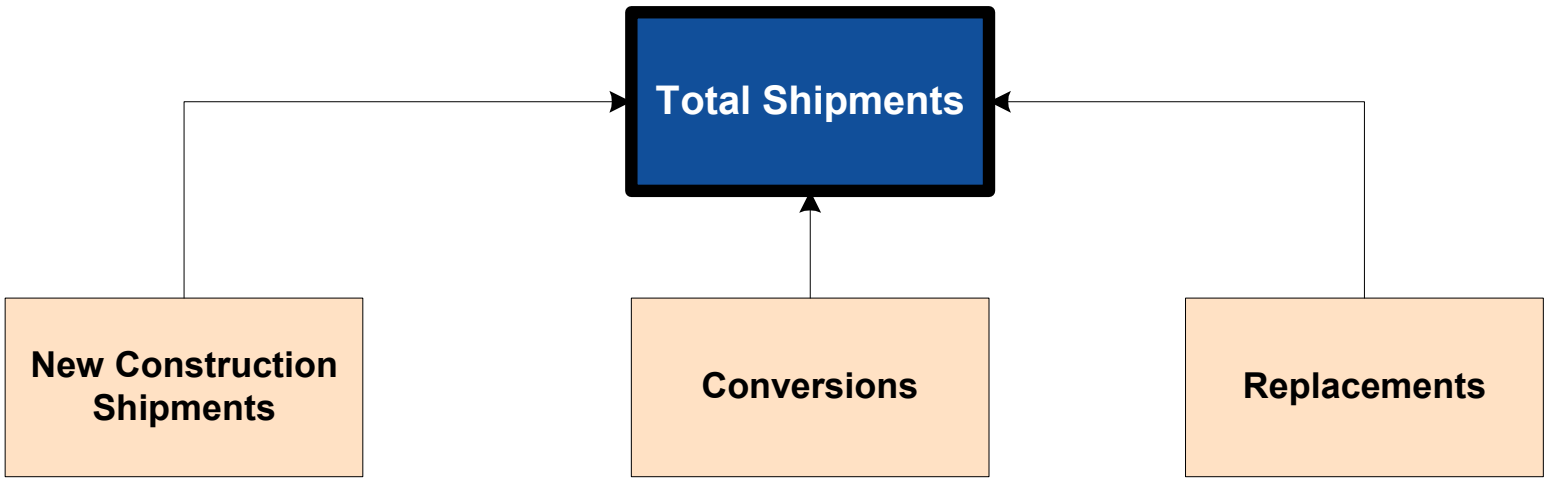
Process Chart



Shipments Model

- Generates base case shipments, which is the case without new equipment standards, and a standard case shipments, which is the case assuming new equipment standards have taken effect (for the years 2012-2035)
- Accounts for equipment installed in new housing, conversions and replacements to develop the total shipments
- Provides retirements forecast according to age distribution of furnaces in each year.
- Incorporates market share model to account for fuel switching

Shipments Flowchart

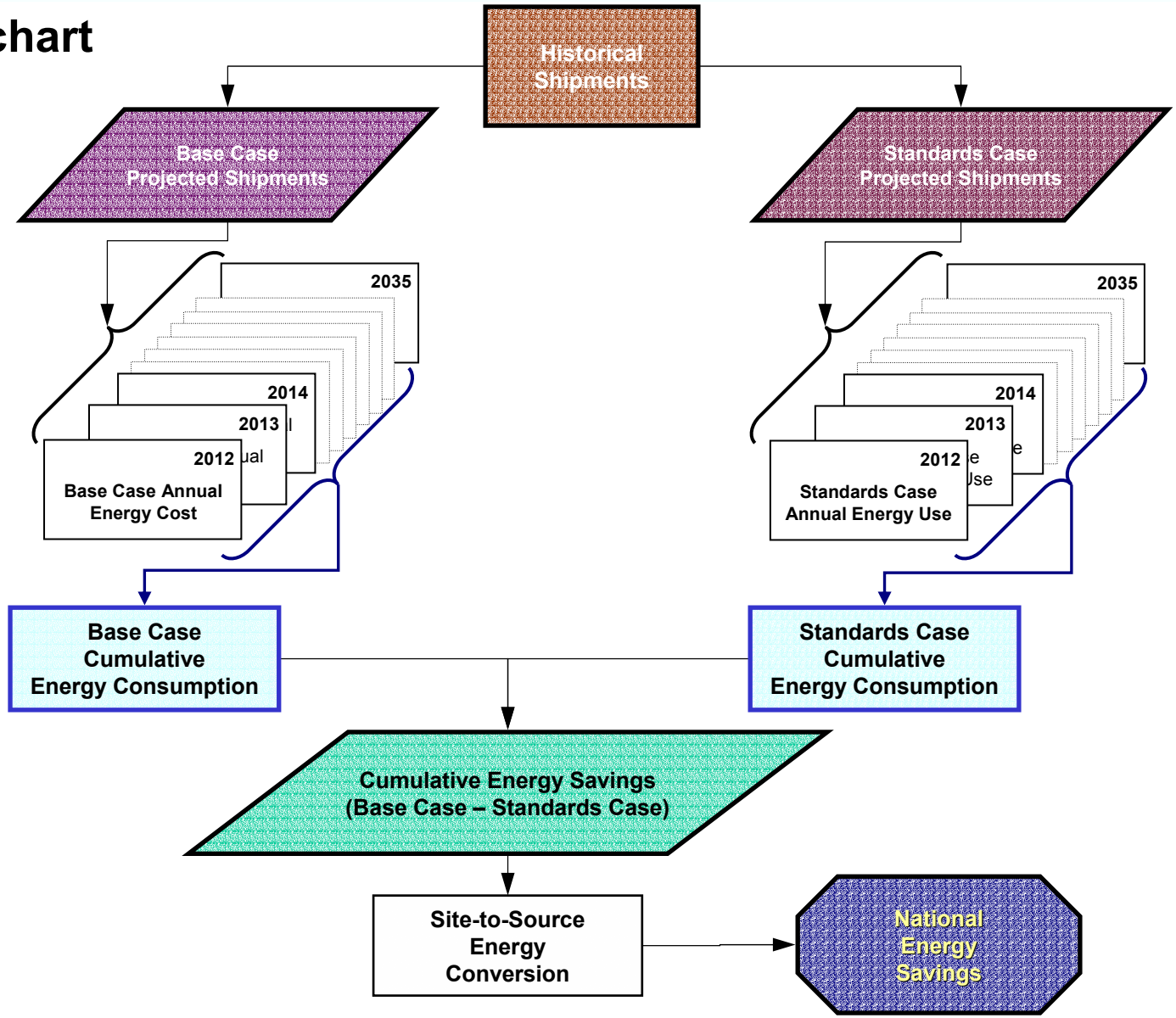


- Install heating systems into new construction

- Replace with equipment utilizing a different fuel

- Replace with same equipment type and same fuel

NES Flowchart



National Energy Savings Key Inputs

Annual Energy Use

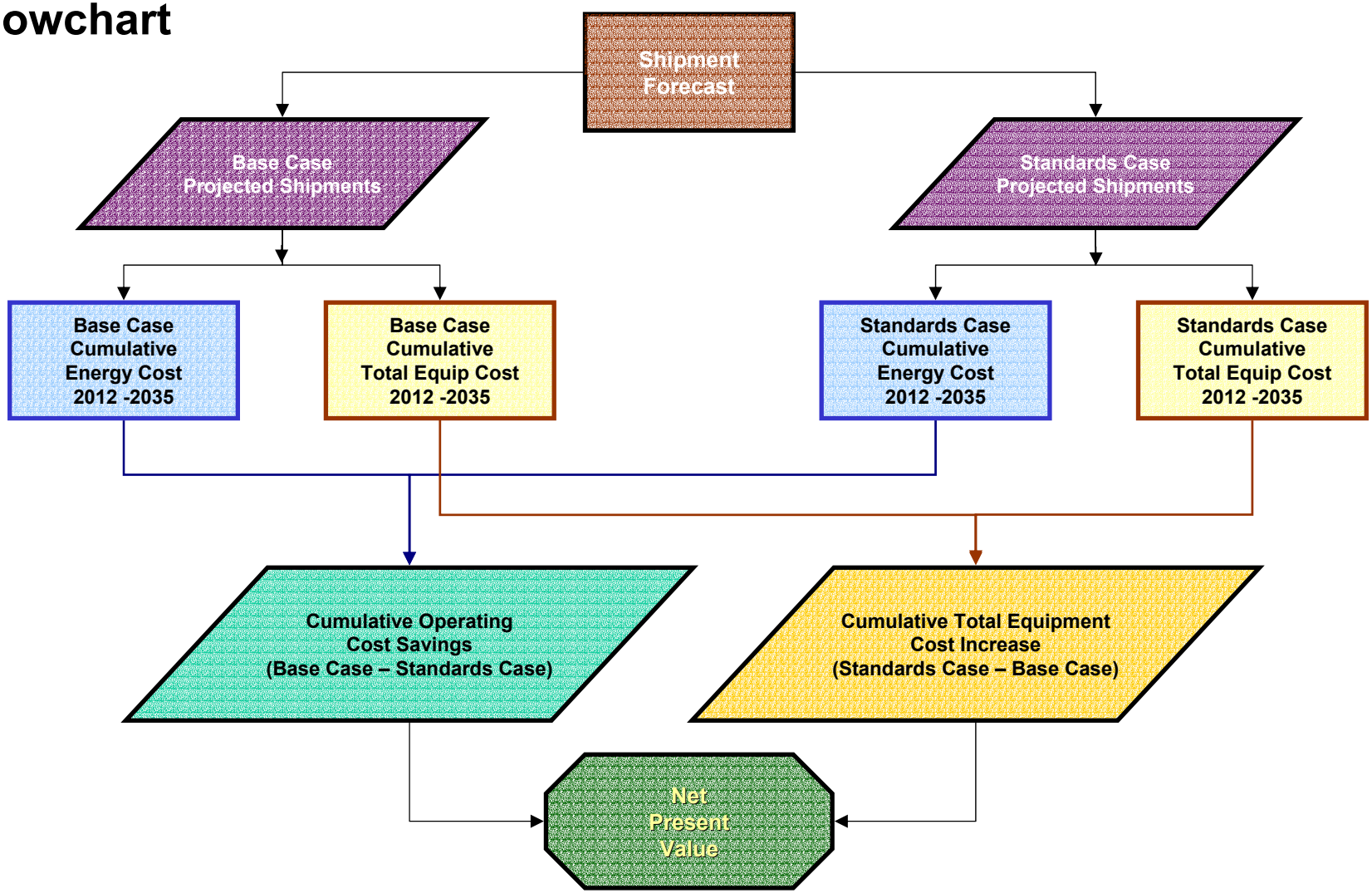
- Weighted average per unit values as a function of efficiency level taken from LCC analysis
- Weighted average calculated according to efficiency market share

National Energy Savings Key Inputs

Site-to-Source Conversion

- Electricity consumed at the site does not equal energy at the power plant
  - Conversion losses
  - Transmission and distribution losses
  - Generation fuel mix and plant efficiency
  - Generation plant mix change over time
- Natural Gas fuel consumed at the site does not equal fuel at the point of extraction
  - Production losses
  - Transmission and distribution losses
- Conversion done with DOE's National Energy Modeling System (NEMS)

National NPV Flowchart

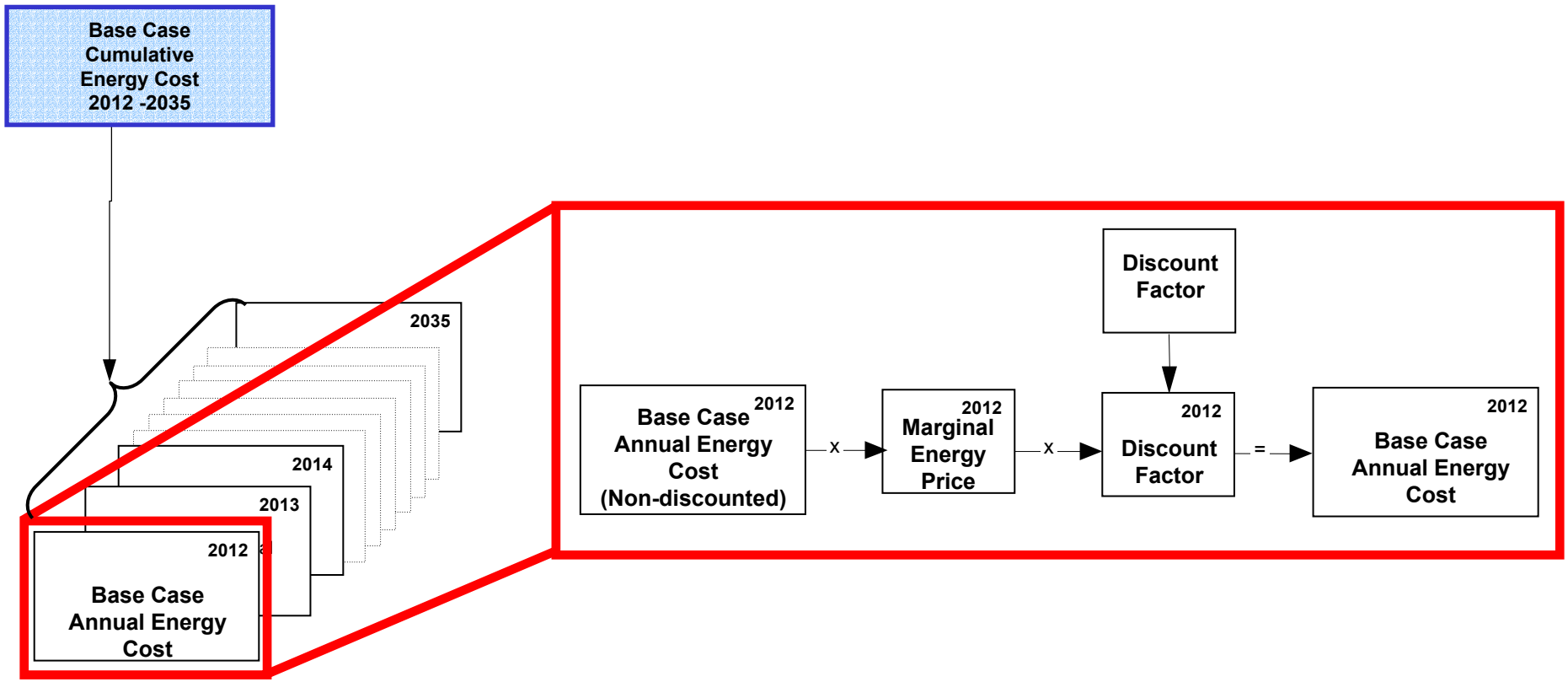


National Net Present Value Key Inputs

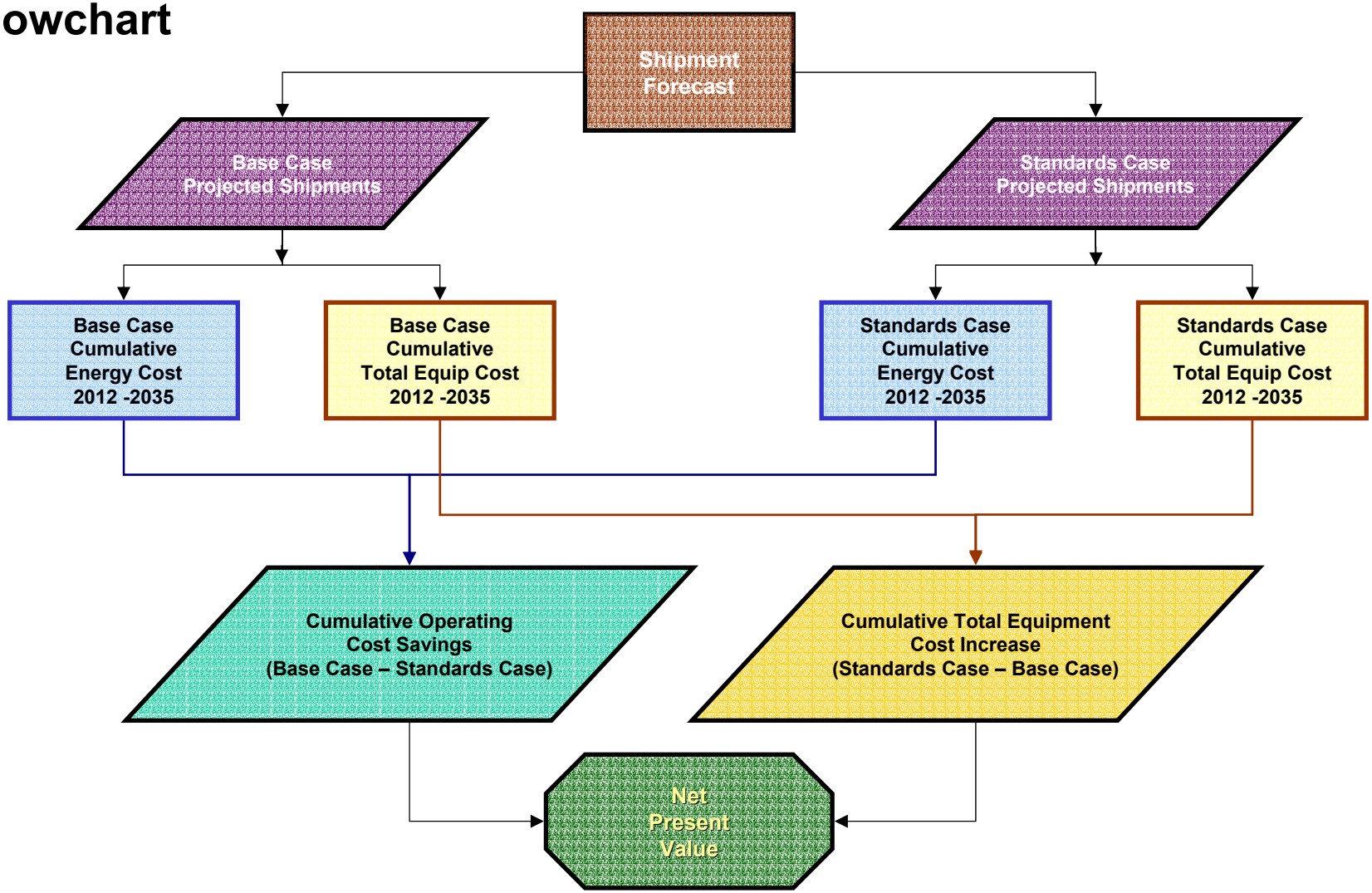
Discount Rate

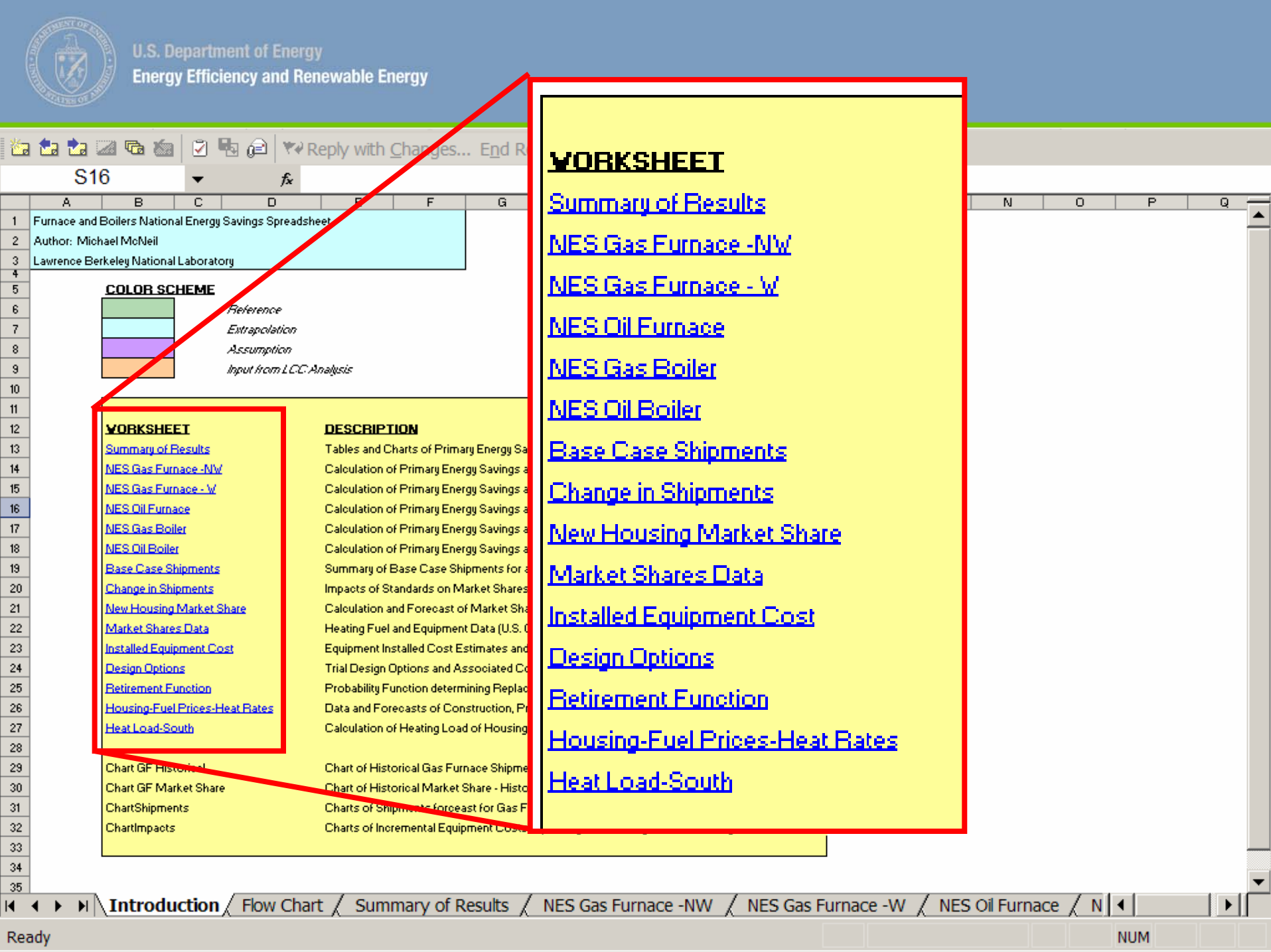
- National average
- Office of Management and Budget (OMB) mandated 7% and 3% real

Annual Energy Cost



National NPV Flowchart




U.S. Department of Energy
Energy Efficiency and Renewable Energy
Reply with Changes... End R
S16
Furnace and Boilers National Energy Savings Spreadsheet
Author: Michael McNeil
Lawrence Berkeley National Laboratory
COLOR SCHEME
Reference
Extrapolation
Assumption
Input from LCC Analysis
WORKSHEET
DESCRIPTION
Summary of Results
Tables and Charts of Primary Energy Sa
NES Gas Furnace -NW
Calculation of Primary Energy Savings a
NES Gas Furnace - W
Calculation of Primary Energy Savings a
NES Oil Furnace
Calculation of Primary Energy Savings a
NES Gas Boiler
Calculation of Primary Energy Savings a
NES Oil Boiler
Calculation of Primary Energy Savings a
Base Case Shipments
Summary of Base Case Shipments for a
Change in Shipments
Impacts of Standards on Market Shares
New Housing Market Share
Calculation and Forecast of Market Sha
Market Shares Data
Heating Fuel and Equipment Data (U.S.
Installed Equipment Cost
Equipment Installed Cost Estimates and
Design Options
Trial Design Options and Associated Co
Retirement Function
Probability Function determining Replac
Housing-Fuel Prices-Heat Rates
Data and Forecasts of Construction, Pr
Heat Load-South
Calculation of Heating Load of Housing
Chart GF Historical
Chart of Historical Gas Furnace Shipme
Chart GF Market Share
Chart of Historical Market Share - Histo
ChartShipments
Charts of Shipments forecast for Gas F
ChartImpacts
Charts of Incremental Equipment Cost
WORKSHEET
Summary of Results
NES Gas Furnace -NW
NES Gas Furnace - W
NES Oil Furnace
NES Gas Boiler
NES Oil Boiler
Base Case Shipments
Change in Shipments
New Housing Market Share
Market Shares Data
Installed Equipment Cost
Design Options
Retirement Function
Housing-Fuel Prices-Heat Rates
Heat Load-South
Introduction
Flow Chart
Summary of Results
NES Gas Furnace -NW
NES Gas Furnace -W
NES Oil Furnace
Ready
NUM

AG52

Discount Rate	7%
Current Year	2002
Economic Growth	Reference Case
Furnace Installation Costs	RS Means Data

Source Energy Savings Matrix (Quads)

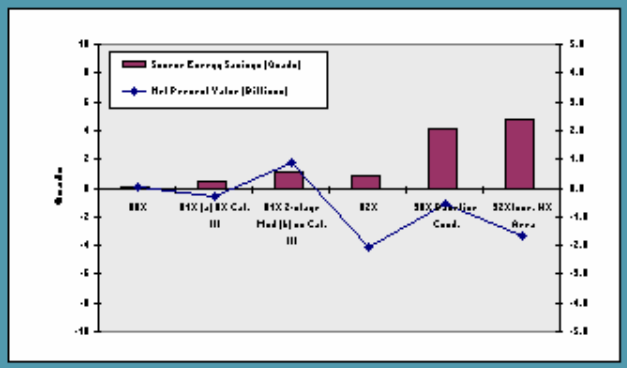
	D.O. 1	D.O. 2	D.O. 3	D.O. 4	D.O. 5	D.O. 6
Gas Furnace - Non W.	0.03	0.44	1.17	0.02	4.18	4.03
Gas Furnace - Weath.	0.01	0.00	0.10	0.00		
Oil Furnace	0.00	0.02	0.04	0.05	0.07	0.03
Gas Boiler	0.03	0.03	0.16	0.24	0.57	1.43
Oil Boiler	0.00	0.01	0.02	0.03	0.03	0.25

Net Present Value Matrix (Billions $2001)

	D.O. 1	D.O. 2	D.O. 3	D.O. 4	D.O. 5	D.O. 6
Gas Furnace - Non W.	0.05	-0.29	0.07	-2.03	-8.55	-1.55
Gas Furnace - Weath.	0.02	0.07	0.14	0.21		
Oil Furnace	0.01	0.04	0.07	0.11	-0.15	-0.11
Gas Boiler	0.02	0.10	0.20	0.33	-0.65	-1.08
Oil Boiler	0.01	0.02	0.03	0.07	-0.20	-0.33

Non-Weatherized Gas Furnaces

	DESIGN OPTION						
	Base Case	88%	94% [a] 88% Cat. III	94% 2-stage Mod [b] on Cat. III	92%	98% Baseline Cond.	92% Incr. HX Area
Shipments 2042-2055 [Millions]	84.6	84.58	84.54	84.49	84.28	80.86	79.58
Net Savings, not discounted [$ Billions]		0.38	1.62	10.75	-5.88	23.87	24.7
Net Present Value [$ Billions]		0.05	-0.29	0.07	-2.03	-8.55	-1.55
Source Savings 2042-2055 [Quads]		0.03	0.44	1.17	0.02	4.18	4.03



Shipments - Gas Furnaces

	All GF - New Housing			Non-Weatherized - All Sources			
Year	Completions	Gas Furnace Share	Total	New Housing	Replacements	Conversions	Total
2010	1.62	54.6%	0.884	0.778	1.72	0.14	2.64
2020							
Base	1.72	54.3%	0.944	0.851	2.38	0.16	3.28
88%		54.3%	0.944	0.83	2.38		3.28
94% [a] 88% Cat. III		54.7%	0.941	0.83	2.38		3.28
98% Baseline Cond.		55.4%	0.943	0.88	2.38		3.26
92% Incr. HX Area		55.8%	0.941	0.76	2.38		3.24

Shipments - Other Product Classes

	New Housing			Total Shipments		
	M.S.%	2020	2030	2042	2020	2030
Oil Furnaces	8.7%	12.1	12.7	0.102	0.093	0.073
Gas Boilers	2.5%	45.8	46.1	0.105	0.113	0.117
Oil Boilers	1.8%	30.8	32.3	0.155	0.113	0.118

NWGF Savings Breakdown

Non-Weatherized Gas Furnaces	PRIMARY ENERGY SAVINGS [QUADS]					
	88	94% [a] 88% Cat. III	94% 2-stage Mod [b] on Cat. III	92	98% Baseline Cond.	92% Incr. HX Area
New Housing Share - Gas - 2010	54.6%	54.6%	54.6%	54.6%	54.6%	54.6%
New Housing Share - Gas - 2012	54.4%	54.2%	54.2%	53.7%	52.3%	52.4%
New Housing Share - Gas - 2020	55.2%	55.0%	55.0%	54.5%	53.7%	53.3%
New Housing Share - Gas - 2030	53.7%	53.5%	53.5%	53.1%	52.4%	52.0%
Gas Efficiency Savings [Quads]	0.03	0.45	1.28	0.03	4.14	5.03
Elec. Eff. Savings [Quads]	0.00	0.03	0.01	0.05	0.24	0.55
Market Shift Gas Savings [Quads]	0.00	0.03	0.04	0.10	0.24	0.55
Market Shift Elec Savings [Quads]	0.00	-0.07	-0.08	-0.22	-0.51	-1.11
Total Primary [Quads]	0.03	0.44	1.17	0.02	4.18	4.03

AG52

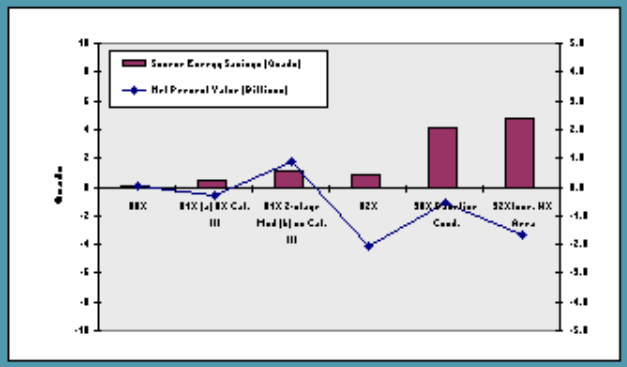
Discount Rate 7%
Current Year 2002
Economic Growth Reference Case
Furnace Installation Costs RS Mean Data

Source Energy Savings Matrix (Quads)

Net Present Value Matrix (Billions $2001)

Non-Weatherized Gas Furnaces

Shipments - Gas Furnaces



NES Oil Furnace / NES Gas Boiler / NES Oil Boiler / Base Case Shipments / Change in Shipments / New Housing Market

Ready NUM

U.S. Department of Energy
Energy Efficiency and Renewable Energy

AG52

Discount Rate 7%
Current Year 2002
Economic Growth Reference Case
Furnace Installation Costs RS Mean Data

Source Energy Savings Matrix (Quads)

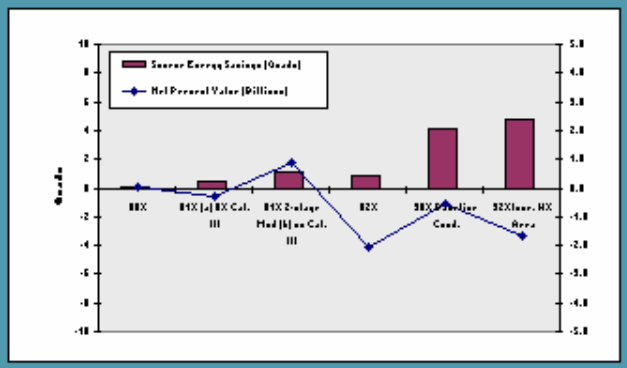
	D.O. 1	D.O. 2	D.O. 3	D.O. 4	D.O. 5	D.O. 6
Gas Furnace - Non W.	0.03	0.44	1.17	0.82	4.18	4.83
Gas Furnace - Weath.	0.01	0.08	0.18	0.38		
Oil Furnace	0.00	0.02	0.04	0.05	0.07	
Gas Boiler	0.03	0.03	0.16	0.24	0.57	
Oil Boiler	0.00	0.01	0.02	0.03	0.03	

Net Present Value Matrix (Billions $2001)

	D.O. 1	D.O. 2	D.O. 3	D.O. 4	D.O. 5
Gas Furnace - Non W.		-0.29	0.07	-2.03	-8.56
Gas Furnace - Weath.	0.02	0.07	0.14	0.24	
Oil Furnace	0.01	0.04	0.07	0.11	-0.15
Gas Boiler	0.02		0.20	0.33	-0.65
Oil Boiler	0.01	0.02	0.03	0.07	-0.28

Non-Weatherized Gas Furnaces

	DESIGN OPTION				
	Base Case	88X	84X [+] 88X Col. III	84X [+] 88X Mod [&] so Col. III	92X
Shipments 2002-2035 [Millions]	84.6	84.68	84.51	84.43	
Net Savings, not discounted [$ Billions]		0.38	1.62	10.75	
Net Present Value [$ Billions]		0.05	-0.29	0.07	-2.03
Source Savings 2002-2035 [Quads]		0.03	0.44	1.17	0.82



Shipments - Gas Furnaces

Year	All GF - New Housing			Non-Weatherized - All Sources			
		Gas Furnace Share	Total	New Housing	Replacements	Conversions	Total
2018	1.62		0.884	0.778	1.72	0.14	2.64
2028							
Base		54.3%	0.544	0.851			3.28
88X		54.3%	0.544	0.83	2.58		3.28

New Housing Share - Gas - 2028	53.7%	53.6%	53.5%	53.1%	52.4%	52.8%
Gas Efficiency Savings [Quads]	0.03	0.45	1.28	0.83	4.14	5.83
Elec. Eff. Savings [Quads]	0.00	0.03	0.01	0.05	0.24	0.55
Market Shift Gas Savings [Quads]	0.00	0.03	0.04	0.10	0.24	0.65
Market Shift Elec Savings [Quads]	0.00	-0.07	-0.08	-0.22	-0.51	-1.41
Total Primary [Quads]	0.03	0.44	1.17	0.82	4.18	4.83

NES Oil Furnace | NES Gas Boiler | NES Oil Boiler | Base Case Shipments | Change in Shipments | New Housing Market

Ready NUM

AG52

Discount Rate 7%
Current Year 2002
Economic Growth: Reference Case
Furnace Installation Costs: RS Mean Data

Source Energy Savings Matrix (Quads)

	D.O. 1	D.O. 2	D.O. 3	D.O. 4	D.O. 5	D.O. 6
Gas Furnace - Non W.	0.03	0.44	1.17	0.82	4.18	4.83
Gas Furnace - Weath.	0.01	0.08	0.18	0.38		
Oil Furnace	0.00	0.02	0.04	0.05	0.07	
Gas Boiler	0.03	0.03	0.16	0.24	0.57	
Oil Boiler	0.00	0.01	0.02	0.03	0.03	

Net Present Value Matrix (Billions $2001)

	D.O. 1	D.O. 2	D.O. 3	D.O. 4	D.O. 5
Gas Furnace - Non W.		-0.29	0.07	-2.03	-8.58
Gas Furnace - Weath.	0.02	0.07	0.14	0.24	
Oil Furnace	0.01	0.04	0.07	0.11	-0.15
Gas Boiler	0.02		0.28	0.33	-0.52
Oil Boiler	0.01	0.02	0.05	0.07	-0.28

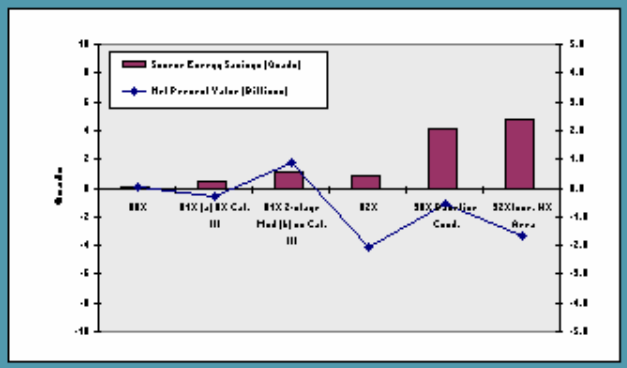
Non-Weatherized Gas Furnaces

	DESIGN OPTION					
	Base Case	88X	84X [+] 88X Col. III	84X [+] Mod [&] Col. III	82X	
Shipments 2002-2035 [Millions]	84.6	84.68	84.51	84.43		
Net Savings, not discounted [$ Billions]		0.38	1.62	10.75		
Net Present Value [$ Billions]		0.05	-0.29	0.07	-2.03	
Source Savings 2002-2035 [Quads]		0.03	0.44	1.17	0.82	4.18

Shipments - Gas Furnaces

Year	All GF - New Housing			Non-Weatherized - All Sectors			
		Gas Furnace Share	Total	New Housing	Replacements	Conversions	Total
2010	1.62		0.884	0.778	1.72	0.14	2.64
2020							
Base		54.3%	0.544	0.851			3.28
88X		54.3%	0.544	0.85	2.58		3.28

New Housing Share - Gas - 2030	53.7%	53.6%	53.5%	53.1%	52.4%	52.0%
Gas Efficiency Savings [Quads]	0.03	0.45	1.28	0.83	4.14	5.83
Elec. Eff. Savings [Quads]	0.00	0.03	0.01	0.05	0.24	0.56
Market Shift Gas Savings [Quads]	0.00	0.03	0.04	0.10	0.24	0.65
Market Shift Elec Savings [Quads]	0.00	-0.07	-0.08	-0.22	-0.51	-1.41
Total Primary [Quads]	0.03	0.44	1.17	0.82	4.18	4.83



NES Oil Furnace | NES Gas Boiler | NES Oil Boiler | Base Case Shipments | Change in Shipments | New Housing Market

Ready NUM

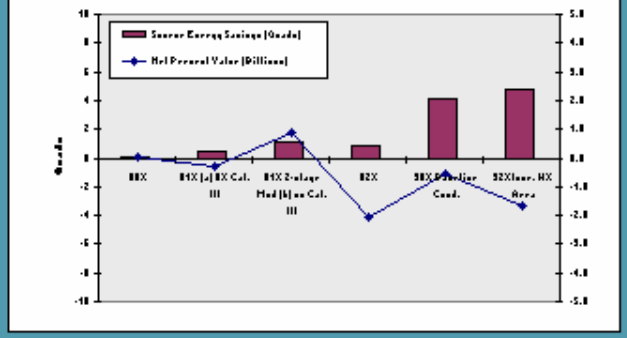
AG52

Non-Weatherized Gas Furnaces

	DESIGN OPTION						
	Base Case	80%	81% (a) 8% Cat. III	81% 2-stage Mod (b) no Cat. III	82%	90% Baseline Cond.	92%Incr. HX Area
Shipments 2012-2035 (Millions)	81.6	81.60	81.51	81.49	81.28	80.86	79.50
Net Savings, not discounted ($ Billions)		0.38	1.62	10.75	-3.00	23.87	21.7
Net Present Value ($ Billions)		0.05	-0.29	0.87	-2.03	-0.56	-1.66
Source Savings 2012- 2035 (Quads)		0.03	0.44	1.17	0.82	4.10	4.83

Non-Weatherized Gas Furnaces

NWGF Savings Breakdown

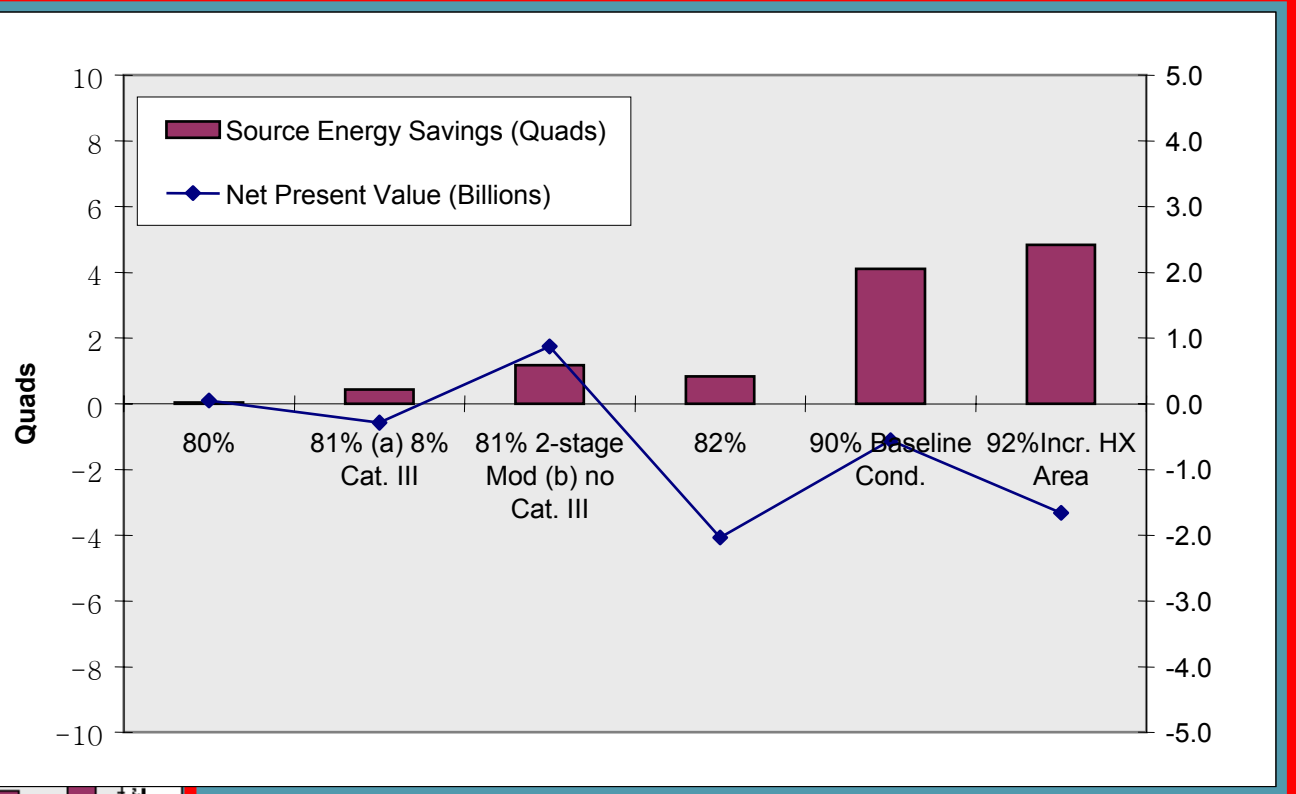


NES Oil Furnace | NES Gas Boiler | NES Oil Boiler | Base Case Shipments | Change in Shipments | New Housing Market

Ready

NUM

AG52



Source Energy Savings Matrix (Qu

Gas Furnace - Non W.	
Gas Furnace - Weath.	
Oil Furnace	
Gas Boiler	
Oil Boiler	

Net Present Value Matrix (Billions

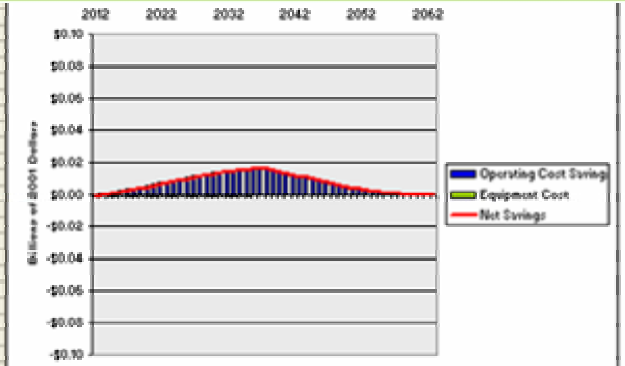
Gas Furnace - Non W.	
Gas Furnace - Weath.	
Oil Furnace	
Gas Boiler	
Oil Boiler	

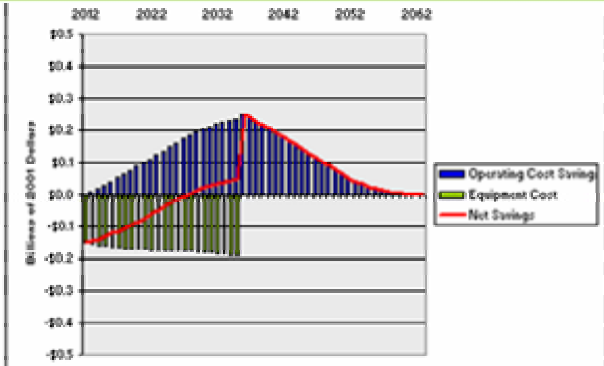
Non-Weatherized Gas Furnaces

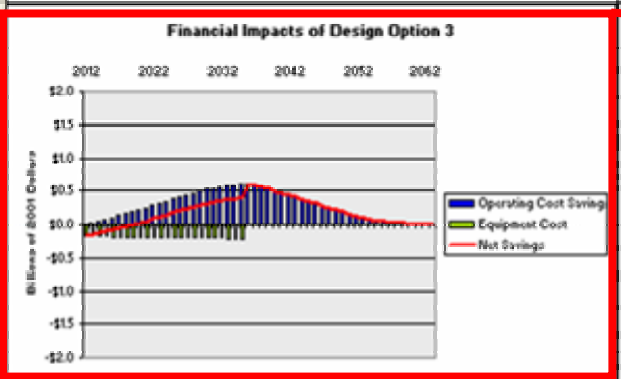
NES Oil Furnace | NES Gas Boiler | NES Oil Boiler | Base Case Shipments | Change in Shipments | New Housing Market

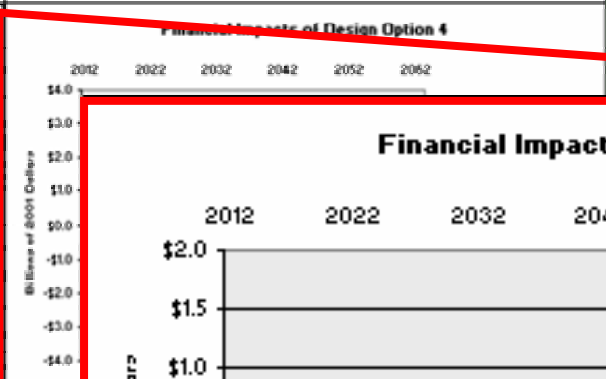
Ready

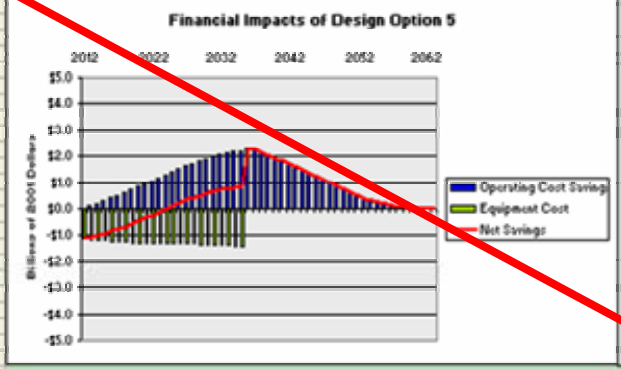
NUM

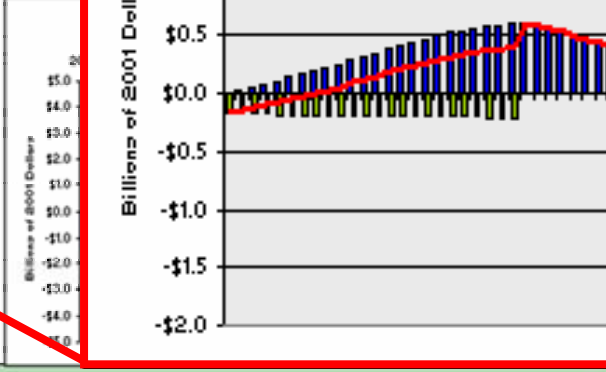












Retirement Function | Housing-Fuel Prices-Heat Rates | Heat Load-South | Chart GF Historical | Chart GF Market Share | ChartShipments | NWGF Financial Impacts

Thank you and for more information…

- U.S. Department of Energy Appliance Rulemaking Website
  - www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
- U.S. Department of Energy
  - Mohammed Khan tel: 202 586 7892, mohammed.khan@ee.doe.gov
- Lawrence Berkeley National Laboratory
  - Alex Lekov tel: 510 486 6849, ablekov@lbl.gov
  - James Lutz tel: 510 486 7302, jdlutz@lbl.gov
- Navigant Consulting
  - Graham Stevens tel: 202 973 8405, gstevens@navigantconsulting.com